POWER

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Finding and Leaving

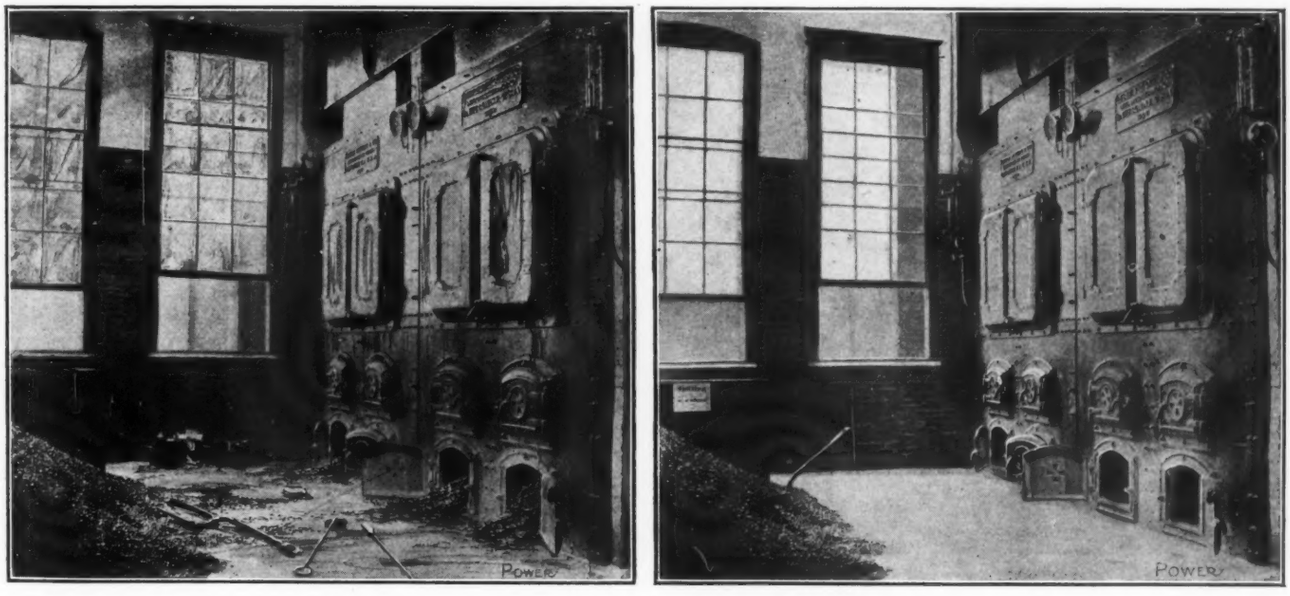
Did you ever say, "If the way I do things don't suit the other fellow, he can do them to suit himself?"

Hardly the expression of a progressive engineer, but one that has been voiced many times in small steam plants, running on a day and night shift. But if a man has done his work the best he knows how, there will not be a feeling that the other fellow will not be satisfied.

In small plants, in which a day and a night engineer are employed, frequent opportunities for friction arise, although it is generally understood that the day man is in charge of the plant. Sometimes he is the more capable of the two, again he is not. Both feel capable of operating the plant and generally each feels that he is the better.

If both pull together, satisfactory operation will result; if one pulls one way and the other another, discord and unsatisfactory results are sure to follow.

A common cause for discord is shirking on the part of one of the engineers. Neither should come on duty and find the fires dirty, the ashpit full of refuse, coal and ashes strewn all over the boiler room floor, boiler fronts dusty and the tubes full of soot. The engine room should also be found clean, the engine wiped, oil cups filled and the tools in their proper places.



The Wrong and the Right Way to Leave the Fire Room.

Many engineers, rather than work with the dirt of other men about, will clean it up, thus doing labor that does not belong to their shift.

But because he does this extra work, do not put him down as an "easy mark." He is the better man of the two and shows his true calibre. He will find his proper place in a larger plant at better pay.

The shirker will, unless he changes his ways, continue to chuckle at his success in forcing another to do his work, and will finish his career in a fourth-rate steam plant, at about $12 per week, disgruntled and disliked.

Losses in the Steam Cylinder

By Prof. R. C. H. Heck

A study of general relations and various steam quantities, calculation of indicated steam consumption, and the construction of the diagram of specific steam rates.

Perhaps the clearest and most comprehensive understanding of the losses occurring in a steam-engine cylinder can be got by considering first the ideal case in which these losses would be absent, then comparing actual with ideal performance.

The essential actions upon or the working medium in any heat-engine plant are, to receive heat from the source, convert part of it into work, and reject the remainder. In the steam plant these are quite distinctly separated, constituting the respective functions of the boiler, of the engine cylinder, and of the condenser (often the atmosphere). Obviously the cylinder will best serve its purpose if it does not encroach upon the purely thermal functions of imparting and abstracting heat.

What takes place in the ideal heat

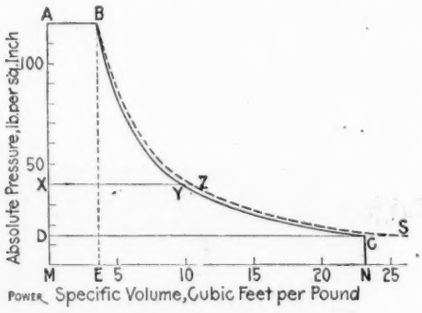


FIG. 1. THE RANKINE CYCLE

engine is represented by the diagram, Fig. 1, generally called the Rankine cycle. In a general discussion, it is convenient and proper to consider the performance of the unit weight of steam, rather than the particular quantity which a certain engine would use per revolution. Fig. 1 is therefore drawn in true proportions for 1 lb. of steam, with the limiting pressures 120 lb. and 15 lb. per sq.in., abs. The cylinder is assumed to have no clearance space and to be thermally neutral, as if made of some imaginary substance which can neither absorb nor conduct heat.

With theoretically perfect conditions, there would be no pipe and valve losses; then the height *MA* represents the pressure and the length *AB* or *ME* the volume of the pound of steam, both when leaving the boiler and when entering the cylinder. As the simplest case, the steam is taken to be dry and saturated at *B*, but the same kind of ideal operation can be reasoned out for steam that is initially either wet or superheated. The heat received from the fire is brought into the cylinder unchanged, neither diminished in amount by escape through the pipe walls, nor impaired in usefulness by pressure drop due to pipe friction or other throttling action. Then at the cutoff point *B* the pound of steam carries its full internal or intrinsic energy, and the area *ABEMA* shows the external work of vaporization, finally carried over to and performed upon the piston. The heat in the steam at *B*, plus the external work *ABEMA*, constitutes the "total heat" of the pound of steam.

Because the cylinder can neither absorb, give off, nor transmit heat, the expansion *BC* must be adiabatic, or the work performance beyond and after *B* must be wholly by virtue of the store of energy received from the outside source (the fire). The work upon the piston, area *BCNEB*, in relation to the heat con-

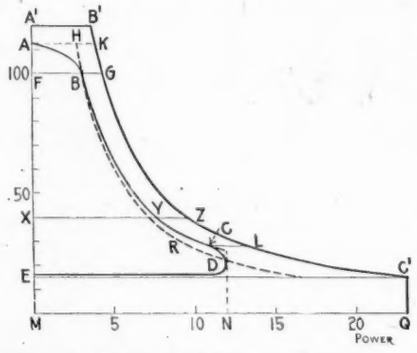


FIG. 2. DIAGRAM SHOWING EFFECT OF PIPE RESISTANCE, INITIAL CONDENSATION AND INCOMPLETE EXPANSION

tent at *B*, determines the shape of the curve *BC*. In giving up the heat equivalent of the external work of expansion, the steam partly condenses; the amount of condensation is indicated by drawing the saturation line *BS*, got by laying off from *MA*, at any pressure, the full volume of the pound of steam. It may be noticed that the expansion is complete, or is continued until the line *DC* of exhaust pressure is reached at *C*. This line *CD* shows complete exhaust, which is necessary under the assumption of no clearance space.

Still governed by this last assumption, the diagram of actual performance takes the form *ABCDEA* in Fig. 2. Pipe radiation is eliminated by considering that all water of condensation due to this cause is removed by a separator at the engine. Pipe resistances lower the pressure of the steam from *A'B'* to *AK*, the work represented by area *A'B'KAA'* being changed back to heat and retained as a part of the total heat of the steam that passes the separator. Initial condensation by the cylinder walls cuts down the volume at cutoff to *FB*, and makes the whole expansion curve *BC* lie well within the ideal curve *B'C'*; but because of return of heat from the cylinder walls to the expanding steam, curve *BC* rises considerably, above an adiabatic *BR*, drawn from *B*. -The total lost area *A'B'C'DC-BAA'* is chargeable partly to pipe resistances, partly to incomplete expansion in the drop from *C* to *D*, chiefly to the thermal action of the cylinder walls in diminishing the effective volume to that limited by the curve *BC*.

The actual indicator diagram and the performance which it represents are further complicated by the existence of clearance space and of compression. In Fig. 3 is shown such a diagram with the saturation curve *SS* drawn for the whole weight of steam present during expansion, including the clearance steam. On the average, the latter may be taken as dry saturated at the beginning of compression at *E*; in some cases it probably contains a little moisture, in others some superheating has been detected. Then the weight of steam which has the volume *KE* must be added to the amount of working steam which comes from the

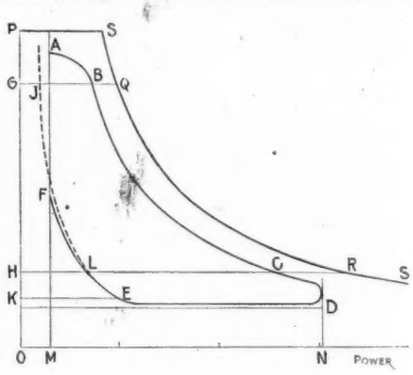


FIG. 3. DIAGRAM SHOWING ACTUAL PERFORMANCE

boiler, to get the total weight for which the curve *SS* is laid out. The question of compression and its effects will later be considered more at length, as one of the main divisions of the subject.

CALCULATION OF INDICATED STEAM CONSUMPTION

Fig. 3 has the pressure and volume data needed for the calculation of indicated steam consumption. The word "steam" is here (and commonly) used to cover the whole mixture of vapor and

liquid; it might be better to speak of the total water present in the cylinder, but that word is rather too closely associated with the liquid state. Consider the illustration to be an ordinary indicator diagram, showing the performance of the particular quantity of steam used by some engine in one cylinder end per revolution; the curve *SS*, possible of location only when a measurement of actual steam consumption has been made, may not be definitely known. The length *MN* represents not only the stroke of the piston but also the volume displaced by the piston in one stroke, or the nominal cylinder volume. If *A* is the piston area in square inches and *L* the stroke in feet, this volume is

$$V = \frac{LA}{144}\ cu.ft. \qquad (1)$$

To whatever scale *MN* represents the volume *V*, in the same unit *GB* will measure the space filled with steam at pressure *OG*, *HC* the space at pressure *OH*, and *KE* the space at pressure *OK*, the clearance *OM* being included in all these volumes of steam present. It is convenient to use the ratios

$$e_1 = \frac{GB}{MN} \quad e_2 = \frac{HC}{MN} \quad c = \frac{KE}{MN} \qquad (2)$$

the symbol *e* referring to the expansion curve, *c* to the compression curve. Considering the cutoff point *B*, and dropping the subscript from *e* for the present, gives the volume out to *B*,

$$V_e = eV \qquad (3)$$

and the volume out to *E*,

$$V_c = cV$$

Now saturated steam has the special property—differing from air or any dry gas—that only the pressure need be known to fix the volume per pound or the weight per cubic foot, both usually given as columns in the steam table. Letting *d* (for density) represent the latter quantity, d_e will be used for the pressure p_e or *OG*, d_c for the pressure p_c or *OK*; then the weight of total steam—that is, working steam plus clearance steam—contained in the cylinder with the piston at *B*, is

$$w_e = e d_c\ V\ lb. \qquad (4)$$

while the weight of clearance steam alone at *E* is

$$w_c = c d_c\ V\ lb. \qquad (5)$$

Evidently, the steam apparently consumed per revolution, or the indicated weight of the working steam by itself, is

$$w = w_e - w_c = (ed_e - cd_c)\ V = k\,V \qquad (6)$$

The factor in parentheses, for which the symbol *k* will be used, indicates the weight of net indicated steam per cubic foot of piston displacement. This is clearly apparent if both sides of equation (6) be divided by *V*; for then

$$\frac{w}{V} = k \qquad (7)$$

and *w/V* is certainly the steam weight per revolution per cubic foot of nominal cylinder volume. In analogy to specific volume (volume of the unit of weight) and specific weight (weight of the unit of volume), the steam rate *k* per unit of displacement will be called the specific steam consumption or steam rate. Upon this conception is based the graphical method of representing steam consumption to be taken up later. By the use of this method actual steam, indicated steam, missing steam, clearance steam, etc., can be equally well diagrammed.

Between the quantity *k* and the corresponding rate in pounds per horsepower-hour there is a very simple relation, which is perfectly well known but for completeness of presentation had better be deduced here. Since *w* in equation (6) is the weight per revolution, it must be multiplied by the revolutions per minute, *N*, to get steam per minute and by 60 to get steam per hour. Then the weight *W* per hour, giving *V* the value in equation (1), is

$$W = \frac{60\ LAN}{144} \times k \qquad (8)$$

Dividing this by the indicated horsepower,

$$H = \frac{PLAN}{33{,}000}$$

gives the steam rate W_H in pounds per horsepower-hour

$$W_H = \frac{13{,}750}{P} \times k \qquad (9)$$

where *P* is the mean effective pressure in pounds per square inch.

Various Steam Quantities

Returning to Fig. 3, the working assumption will be made that the clearance steam is dry saturated at the point *E*, the beginning of compression; then its actual weight is given by the volume *KE* as

$$w_c = c d_c V = k_c V \qquad (10)$$

according to equation (5). From *E* carry up a (dotted) curve of constant steam weight, cutting the line *HC* at *L* and *GB* at *J*; then *HL* and *GJ* represent the same weight w_c.

If the actual consumption of working steam has been determined, whether by the weighing of feed water or of the discharge from a surface condenser, the weight *w* will be laid out as *JQ* or *LR*; or, in general, it will locate the constant-weight curve *SS* for the total steam $(w + w_c)$. Between the indicated working steam w_i given by equation (6) and shown, in changing value, by *JB*, *LC*, etc.—and the actual steam *w* lies the missing quantity w_m, represented by *BQ* or *CR*. This is really present in the form of water, except as the deficiency w_m may be partly due to leakage, but is of such insignificant bulk that it fails to make any impression upon the volume which gives the indicated steam. The subscript *m* may be thought of as standing for "missing" or as related to the moisture fraction *m*. If the shrinkage from *GQ* to *GB* were all due to cylinder condensation,

$$= \frac{BQ}{JQ} = \frac{w_m}{w} \qquad (11)$$

would measure the moisture in the cylinder at *B*, expressing it as a fraction of the weight of steam admitted.

In the ordinary practical workup of indicator diagrams, which goes no farther than the calculation of indicated horsepower and steam consumption, the missing steam is referred to or compared with the working steam, after the manner of equation (11). It is more logical, however, to let *m* represent the ratio of *BQ* to *GQ*, or of missing steam to total steam, and this is done when the closer thermal analysis of steam action is undertaken. The complement of the moisture fraction as thus defined, or $x = (1 - m)$, is the quality fraction for the whole steam in the cylinder, assuming that none has escaped by leakage.

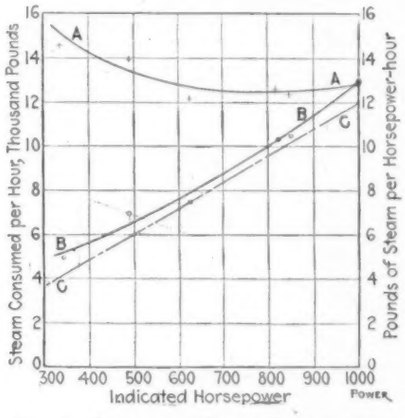


Fig. 4. Curves of Total Steam and Steam Per Horsepower

The missing quantity *BQ* at cutoff is of strong interest; it fixes the effective initial volume of the unit weight of steam, and is quite closely proportional to the amount of heat yielded to the cylinder walls by the steam, or can with little difficulty be adjusted into such proportionality. But as expansion progresses, the volume between curves *BC* and *QR* bears a less and less direct relation to heat interchanged. As a help in comparing realized with ideal performance, the missing quantity *CR* at release is of less value than would be the volume or weight between *C* and an adiabatic curve from *Q*, like *CL* in Fig. 2. The useful result got by calculating indicated steam at release is the difference between the weights corresponding to volumes *CL* and *BJ*, or the increases in steam weight due to reëvaporation.

The Diagram of Specific Steam Rates

In Fig. 4 is given an example of the two curves commonly used for showing

the steam consumption of an engine; these are, the curve *AA* of steam per horsepower-hour and the curve *BB* of total steam used per hour. The tests selected for illustrative purposes were made by Professor Jacobus upon a 20 and 40 by 42-in. cross-compound Corliss engine, and are published in the *Transactions* of the American Society of Mechanical Engineers, Vol. 24, page 1274. The engine had full jackets (on the heads and barrel of each cylinder) and a reheating receiver; the steam pressure was 150 lb. gage and the average pressure in the condenser about 1 lb. abs.; the speed varied from 122.7 to 120.6 r.p.m. in a range of loading from 340 to 1000 i.hp.

The first curve in Fig. 4 shows merely a ratio, the second an absolute quantity. For a representation of the secondary steam quantities and a study of their

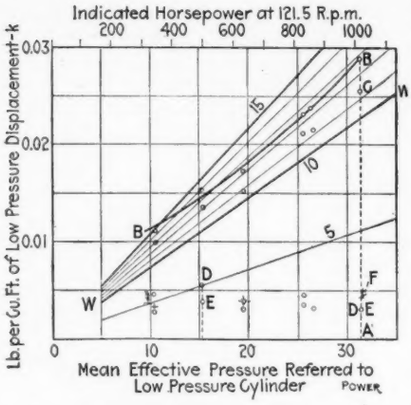


FIG. 5. DIAGRAM OF SPECIFIC STEAM RATES

manner of variation, the latter curve is preferable; and from it is developed the scheme now to be used, exemplified in Fig. 5. In the later diagram, the ordinate is the specific steam consumption k, or the steam per cubic foot of displacement. Division of steam per hour W by the revolutions per hour $60N$ gives the steam w per revolution; further division by nominal volume V gives the specific rate k. In an ordinary double-acting engine this V is the double volume, or the sum of the two forward-stroke displacements by the two piston faces. In analogy to the elimination of the speed and size factors from steam quantity, the base of the diagram is the mean effective pressure, as representing in simplest terms the power developed.

Referring to the lettering along the ordinate for the highest-power test in Fig. 5, the quantities plotted may be described as follows: AB is the total steam consumed by the engine, in cylinders and in jackets; BC is the steam used in the jackets and reheaters; then AC is the cylinder steam k, or the working steam received; CD is the indicated steam k_{ic} at cutoff and CE the indicated steam k_{ir} at release, by equation (6); normally these are different, the second usually the greater because of reëvaporation, as on the other ordinates. Measuring them downward from C, gives the two steam weights most useful in a study of cylinder losses, namely, AD or k_{mc}, the missing steam at cutoff, and DE, the change in steam weight during expansion. Expressed thus in an absolute measure, rather than by ratios or percentages based on other steam quantities, these values are in decidedly the clearer and more useful form.

Finally, AF or k_{mf} is the missing steam at cutoff, according to a formula devised by the writer; it is supposed to agree fairly well with AD, serving as a means for estimating the probable value of the latter. In this set of tests, data for the formula are given in but three out of the six tests made; and the degree of conformity of formula to fact leaves much to be desired.

It may be noticed that in Fig. 5 the mean effective pressure is reduced or referred to the low-pressure cylinder; and, of course, the steam weight k is determined by the volume of that same cylinder, even though the missing steam k_m (using this as a general symbol for AD, AE or AF) belongs to the high-pressure cylinder. Not so much the absolute numerical value of k_m as its relative value in the various tests of a series is the matter of interest.

Two further points will complete this introductory description of methods. From the simple relation set forth in equation (9) is derived a very convenient scheme for making Fig. 5 a diagram of steam per horsepower-hour also. For a given rate W_H,

$$k = \frac{P \times W_H}{13{,}750} \qquad (12)$$

which can be represented by an inclined straight line like WW, starting from the zero point or origin of coördinates. For instance, take $W_H = 10$; then on the ordinate at $P = 30$,

$$k = \frac{30 \times 1}{13{,}750} = 0.0218 \text{ lb.}$$

With this one calculated point and the origin, the line WW is definitely located. A series of these constant-rate lines forms a scale on which the values of any of the steam quantities represented can be read off in pounds per horsepower-hour.

In Fig. 4 the line CC is a similar constant-rate line for a consumption of 12 lb. per hp.-hr., but the calculation of a determining point is more complicated. As a general proposition, the steam weight w per revolution might be used instead of the weight k per cubic foot; the advantage of the latter is to make engines of various sizes more readily comparable. With machines of the same general class, as to range of limiting pressures and of mean effective pressure, results from a number of engines can be plotted in the same diagram, so as to give a striking composite impression of the behavior of the class.

The last thing to be noticed concerning Fig. 5 is the horsepower scale at the top. It is not always desirable to reproduce tables of numerical results; but to make the diagrams carry as much information as possible, without confusion, will be helpful. If the speed of an engine is constant, the indicated horsepower will vary directly as the mean effective pressure. For the mean speed of the engine, the mean effective pressure which corresponds to a certain indicated horsepower is readily calculable, so that it is a simple matter to get a unit of division and step-off points for the horsepower scale.

New McIntosh & Seymour Horizontal Engine

In designing the new type F engine the manufacturer, the McIntosh & Seymour Co., Auburn, N. Y., has taken advantage of its years of experience and has simplified many details of construction tend-

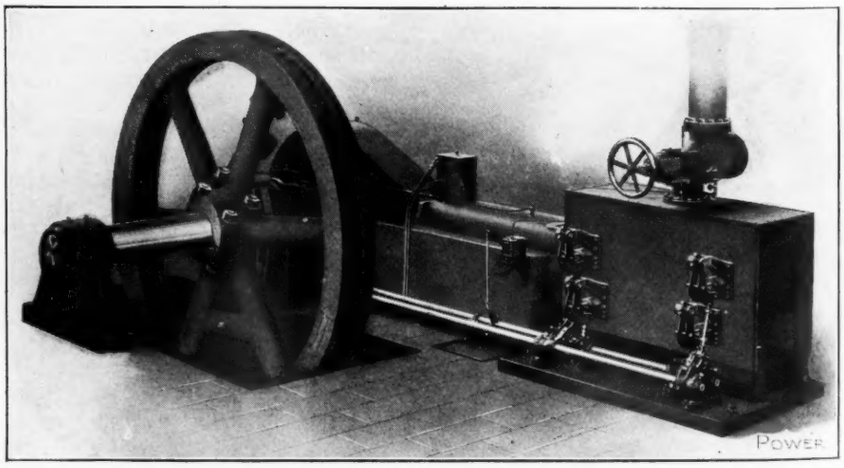


FIG. 1. NEW TYPE F MCINTOSH & SEYMOUR HORIZONTAL ENGINE

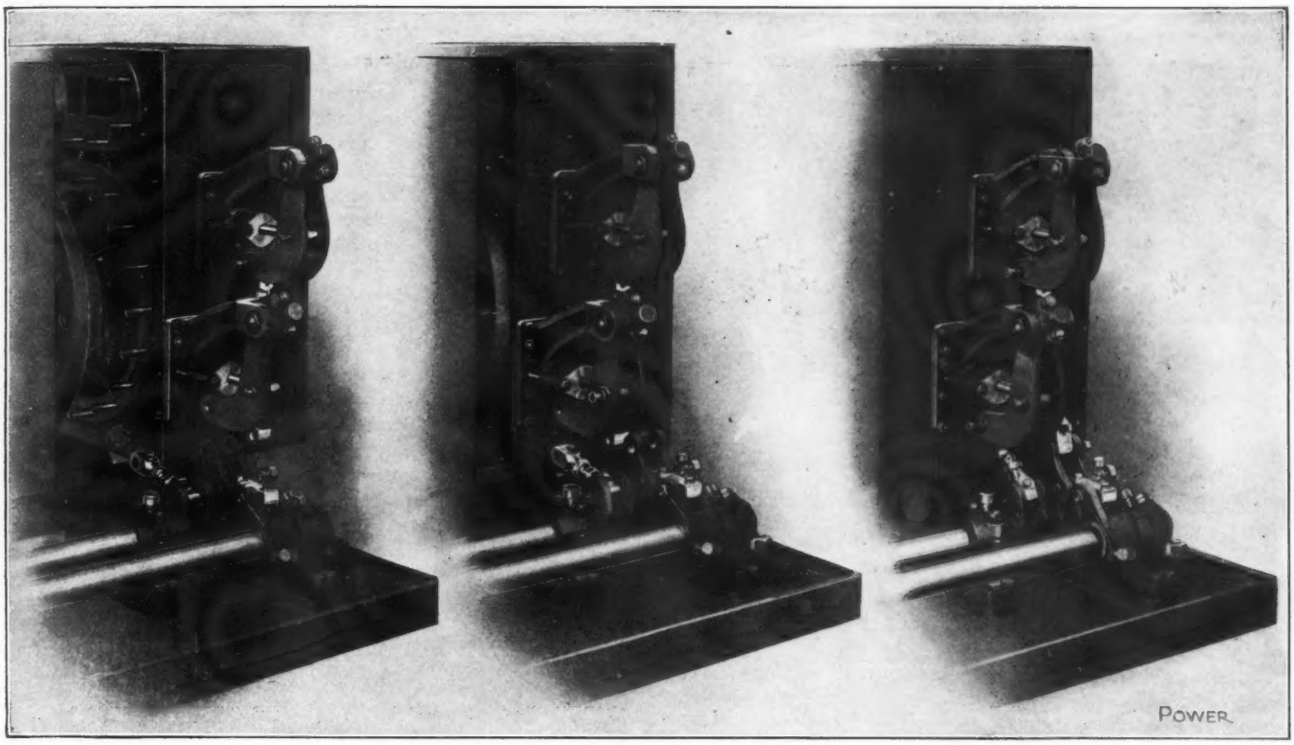


FIG. 2. VALVE GEAR AND REMOVABLE HEAD

ing to increase durability, economy and convenience in handling. The engine is illustrated in Fig. 1.

There are two positively driven steam valves and two exhaust valves, and an exhaust and steam eccentric, the latter controlled by a governor. The steam and exhaust valves are driven by links and bell cranks from rocker-arms on layshafts opposite the cylinder. The special feature of the gear, insuring durability and quiet running, is that the arms or other rocking members, turning upon journals, have means for taking up lost motion.

The four valves are made duplicate and interchangeable as are other parts of the valve-gear, which is arranged to counteract the effect of the angularity of the connecting-rod so as to make the cutoff equal at both ends of the cylinder.

The cylinder casting has a flange at each end through which the cylinder head, containing an exhaust and steam valve, is secured, Fig. 2.

The valve stroke necessary to insure ample opening is small and occurs chiefly when the valve is open and relieved of the pressure of the steam. As there is substantially no movement of the valve when closed the wear is extremely slow, is even and without shoulders since all wearing surfaces on both valves and seat "wipe over." Figs. 3 and 4 show this feature.

Short and direct ports are possible because of the location of the valves in the cylinder heads. The flow of steam is toward the center of the volume displaced by the piston and the form of port is similar to that of a venturi water meter, giving a maximum discharge, a minimum drop of pressure and a minimum final velocity of discharge for a given size of port. This prevents currents of steam impinging upon the walls of the cylinder, thereby causing heat transference and losses from bypassing of heat around the working cycle.

The valves have wipe-over grooves arranged so that steam is admitted at both sides of each port for loads up to nearly full rated capacity. The length of the port edge thus available, is about six times the diameter of the cylinder.

A gridiron valve is used, being peculiarly suitable for placing in the cylinder head, which is removable; practically no more work is necessary than in removing an ordinary cylinder head and its casing.

The quick and easy manner of removing the valve, Fig. 5, affords a means of inspecting, to some extent, the interior of the cylinder by taking out the exhaust valve without disturbing the cylinder head.

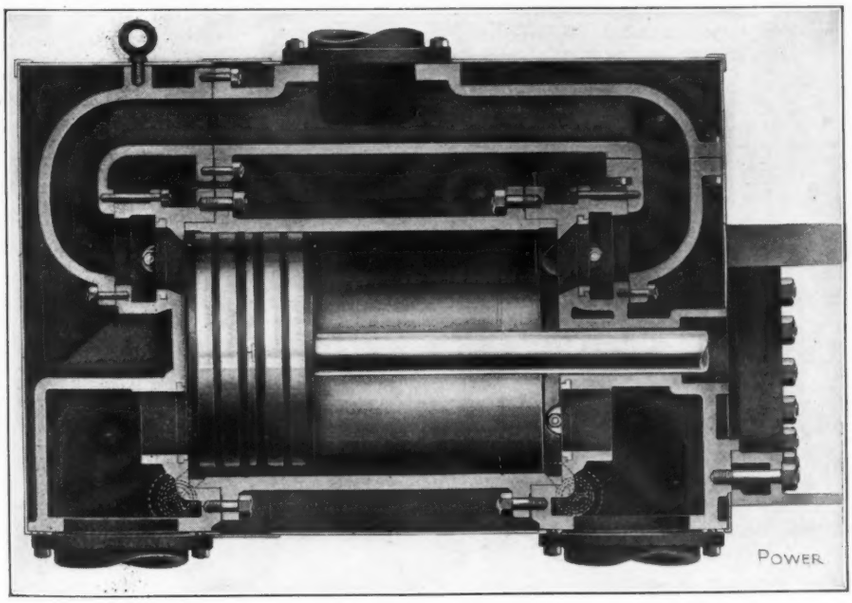


FIG. 3. VERTICAL SECTION THROUGH CYLINDER

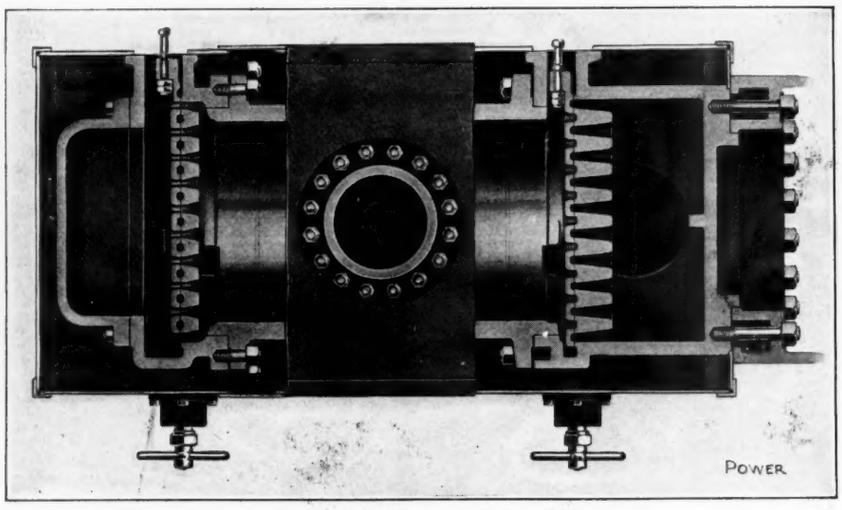


FIG. 4. PARTIAL SECTIONAL VIEW OF CYLINDER SHOWING HEAD-END STEAM AND CRANK-END EXHAUST VALVES

A combination release valve and drip cock is placed in each cylinder head. As the steam valves are free to lift a limited amount, the two features provide security against damage from water in the cylinder.

This engine has a complete oiling system consisting of a receiving tank, water separator and filter, elevating pump to the supply tank above and a series of distributing pipes leading to the sight feeds.

The governor differs from the standard type in that there is but one centrifugal weight which is balanced by the eccentric. The eccentric turns upon a journal ec-

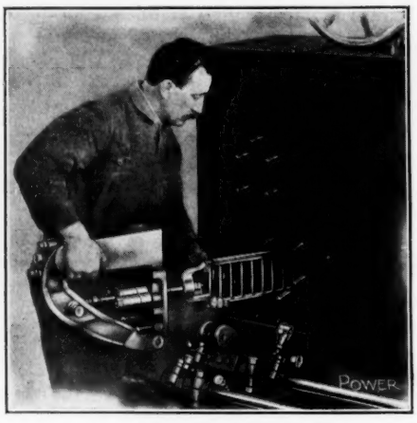


FIG. 5. SHOWING THE EASE WITH WHICH A VALVE CAN BE REMOVED

centric with the shaft instead of turning upon the shaft itself, so that a constant point of admission may be secured to the steam valves with all cutoffs.

The governor is so designed that the combined inertia effect of the different parts due to a change of speed, while it acts in the proper direction to assist the governor, is very slight.

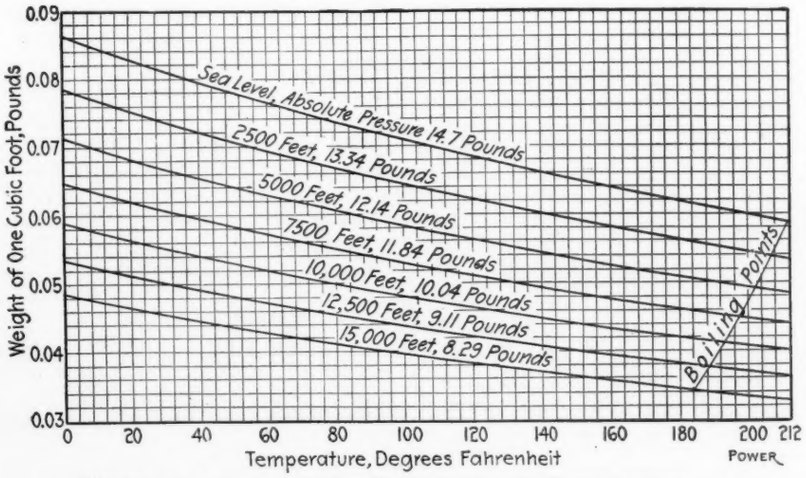
Compressed Air by the Pound

BY FRANK RICHARDS

In statements and computations having to do with the compression and transmission of air the basis or unit of quantity is the volume, usually in cubic feet, of free air, or air at atmospheric pressure, at the time and place under consideration. There are some inconveniences and uncertainties about this practice because the value of the unit is constantly varying with both the altitude, or normal local pressure, and with the temperature. This working volume can always be compared with what would be the volume at sea level and at average temperature, say 60 deg. F., but it is an unwelcome operation.

Knowing the actual quantity of air handled at any time and place would be working with more certainty. If the actual weight of the air is known, it remains the same, whatever the transformations of condition. Pressure, volume and temperature may all vary, but " a pound's a pound for a' that."

To facilitate using the weight basis for records and computations the accompanying table and diagram have been prepared. Computing the items of this table was simple. The weight of a cubic foot of air, whether compressed or not, is obtained by multiplying the constant 2.7093 by the absolute pressure and



WEIGHT OF AIR AT VARIOUS ELEVATIONS AND TEMPERATURES

WEIGHT OF 1 CU.FT. OF FREE AIR AT VARIOUS ALTITUDES AND TEMPERATURES

Temperature Fahr.	Sea level Abs. press. 14.72	2500 ft. Abs. press. 13.34	5000 ft. Abs. press. 12.14	7500 ft. Abs. press. 11.84	10,000 ft. Abs. press. 10.04	12,500 ft. Abs. press. 9.11	15,000 ft. Abs. press. 8.29
0	0.0863	0.0785	0.0713	0.0648	0.0589	0.0535	0.0487
10	0.0845	0.0768	0.0698	0.0635	0.0577	0.0524	0.0477
20	0.0827	0.0752	0.0683	0.0622	0.0565	0.0513	0.0467
30	0.0811	0.0737	0.0669	0.0609	0.0554	0.0503	0.0457
32	0.0807	0.0734	0.0667	0.0606	0.0551	0.0501	0.0455
40	0.0794	0.0722	0.0656	0.0596	0.0542	0.0493	0.0448
50	0.0779	0.0708	0.0643	0.0585	0.0532	0.0483	0.0439
60	0.0764	0.0695	0.0631	0.0574	0.0522	0.0473	0.0431
70	0.0750	0.0682	0.0619	0.0563	0.0512	0.0465	0.0423
80	0.0736	0.0669	0.0608	0.0552	0.0502	0.0456	0.0415
90	0.0723	0.0657	0.0596	0.0542	0.0493	0.0448	0.0408
100	0.0710	0.0645	0.0586	0.0533	0.0484	0.0440	0.0400
110	0.0697	0.0634	0.0578	0.0523	0.0476	0.0432	0.0393
120	0.0685	0.0623	0.0565	0.0514	0.0466	0.0424	0.0386
130	0.0674	0.0612	0.0556	0.0506	0.0459	0.0417	0.0378
140	0.0662	0.0602	0.0549	0.0497	0.0452	0.0410	0.0373
150	0.0651	0.0592	0.0538	0.0489	0.0444	0.0404	0.0367
160	0.0641	0.0583	0.0529	0.0481	0.0438	0.0397	0.0361
170	0.0631	0.0573	0.0521	0.0473	0.0431	0.0391	0.0358
180	0.0621	0.0565	0.0513	0.0466	0.0424	0.0383	0.0348
190	0.0612	0.0556	0.0504	0.0459	0.0417	0.0379	0.0343
200	0.0602	0.0547	0.0497	0.0452	0.0411	0.0373	0.0338
210	0.0593	0.0539	0.0489	0.0445	0.0405	0.0368	0.0332
212	0.0591	0.0538	0.0488	0.0444	0.0404	0.0366	0.0331

dividing the product by the absolute temperature. Thus the weight of 1 cu.ft. of air at an altitude of 10,000 ft. (absolute pressure 10.04 lb.) at 80 deg. F. is

$$\frac{2.7093 \times 10.04}{80 + 461} = 0.0502 \text{ lb.}$$

The diagram embodies all the data comprised in the table, while the curve at the right hand, where it cuts the altitude curves, gives the boiling points of water at those altitudes.

The diagram shows at a glance the differences in weight, or in the actual quantity of air handled, at the different elevations. Thus, to take the extremes, the weight of a cubic foot of free air at sea level and at 60 deg. is 0.0764 lb., while at an elevation of 15,000 ft. the weight of the same volume and at the same temperature is 0.0431, this latter being only 56 per cent. of the former.

In compressing this air to say 100 lb. local gage pressure, the compression at sea level would be

$$\frac{100 + 14.7}{14.7} = 7.8 \text{ atmospheres}$$

while at 15,000 ft. it would be

$$\frac{100 + 8.29}{8.29} = 13.06 \text{ atmospheres}$$

The volume must be reduced to 1/8 in. one case and to 1/13 in the other.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

Hunter explains how a pump handles mine water from the sump to the surface.

A visit to mine pump rooms shows that the pumps are of large size, having capacities up to 25,000 gallons per minute.

One rainy evening, while seated in the lobby of the hotel, I read an account of a cloudburst that had flooded a mine and drowned several miners. The next day, while out for a stroll, I came to a mine, the superintendent of which stated that the water from the river had broken through the roof, and that it had been in a flooded condition for months. All work had been abandoned in the inner workings, and it would require weeks to pump the mine dry and resume operations.

This subject opened up a field upon which Hunter had said nothing, and one which my talk with the superintendent indicated was of vital importance to mine operation.

It wasn't often that I saw Hunter during the day, but entering a street car that afternoon I chanced upon him. We were bound for the same town, quite a few miles distant, so there was plenty of opportunity to talk mine pumps.

"What next?" questioned Hunter, when I asked him what he knew about pumping mine water. "I thought you had about pumped me dry regarding mine matters."

"Just begun," I replied, handing him a "twofer" as we went back to the smoking compartment. "I was at a flooded mine this morning, and it occurred to me that it is going to require some pumping before all of the water is removed. Now, how do they pump water out of a mine that may be anywhere from 50 to 1000 or more feet deep, when a pump will only lift water theoretically about 34 ft.?"

"And is never accomplished," rejoined Hunter. "On the other hand, a duplex pump, placed at or near the bottom of the mine, will easily deliver water in a single lift to the surface, regardless of the depth of the average mine."

"Kind of funny," I replied, chewing the end of my cigar.

"Nothing funny at all. The reason the pump will deliver water to the discharge pipe is because a partial vacuum has been formed in the water cylinder, and the pressure of air on the water supply forces water into the cylinder. If a perfect vacuum were formed by the pump plunger, and no leaks exist, a pump would work with a 33.7-ft. lift. As a perfect vacuum is not obtained a lesser lift of from 22 to 25 ft. is got, with a pump and suction pipe in good condition. A leaky suction pipe will reduce the lift in proportion to the leak, and a serious leak will prevent the pump picking up at all.

"Pumping against a head in a discharge pipe is a different matter. The pump water cylinder is filled with water, and as the piston is forced toward the cylinder head the water escapes through the upper or discharge valves, because there is no other outlet for it, the lower or suction valves being closed by springs as soon as the tension and weight of water is greater than the atmospheric pressure in the suction pipe. With steam

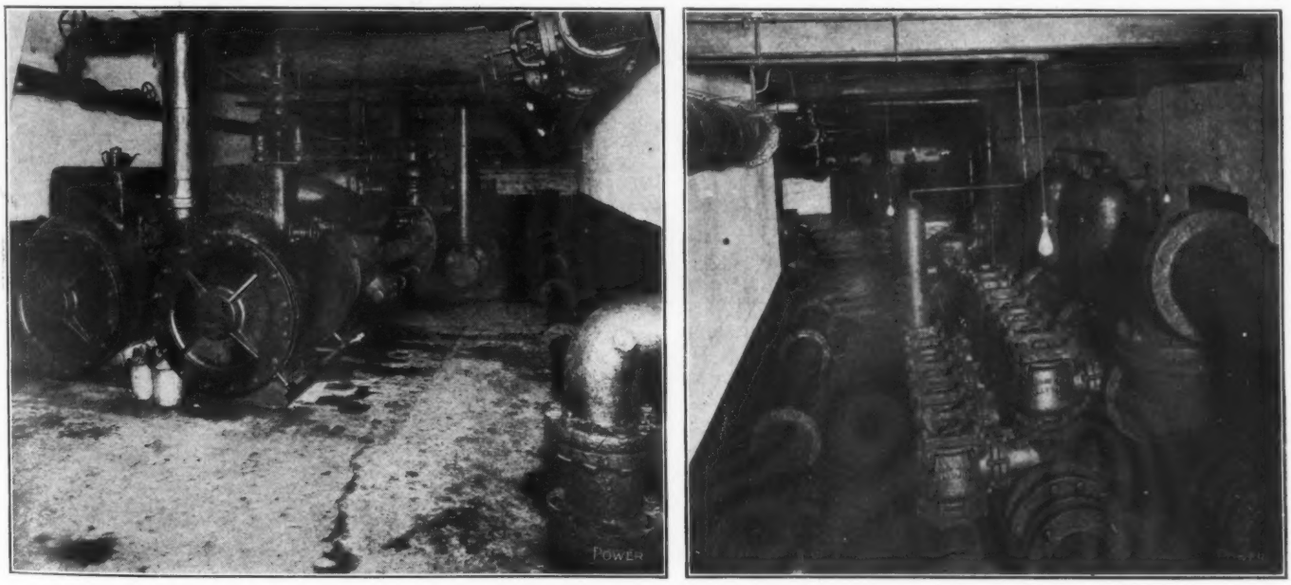


FIG. 1. VIEW OF TWO PUMPS AT THE NO. 9 COLLIERY OF THE PENNSYLVANIA COAL COMPANY

behind the steam piston, the water in the water end will be forced to the top of the mine through the discharge pipe."

"You say that these pumps are placed at or near the bottom of the mine. How can they be used when a mine is flooded? You might as well expect decent service from a waiter without tipping."

Hunter threw the stub end of his cigar out of the window at a stray dog and answered, "Easiest thing in the world. The submerged pumps are out of service, of course, unless air is used in place of steam, but what is known as a sinking pump is used. It is made in a vertical direct-acting type with a steam-actuated valve-gear. It is hung in a vertical position in the shaft, which permits of lowering it as the water recedes in the flooded mine. After the first level has been reached a separate pump can be put to work on that level until the flooded pump has been cleared, when it can be operated to take care of that level of the mine."

"I can see that, but you said that a duplex pump could pump in a single lift, regardless of the depth of the mine. As I remember, a column of water 1 ft. high and 1 sq.in. in area weighes 0.433 lb. Why don't the pump stall when the weight of water in the discharge pipe equals the steam pressure? For instance, if 100 lb. of steam pressure is used in the steam cylinder, why don't the pressure in the discharge pipe equal that in the steam cylinder when the water reaches a height of 231 ft. or a pressure of 100 lb. in the discharge pipe? With a mine 700 ft. deep a steam pressure of over 300 lb. per sq.in. would be required on the steam ends of the pump, which would be some pressure."

Hunter grinned, and pulling a small handbook out of his pocket asked if I had ever noticed the size of pump cylinders.

"You'll find," said he, referring me to the book, "that the water and steam cylinders bear a certain ratio to each other. A simple pump will have a steam cylinder of say 14 in. and a water cylinder of 8 in. in diameter. The first will have an area of 154 sq.in., and the latter a trifle over 50 sq.in. The steam piston would have a total working pressure acting upon it with 100 lb. pressure of 15,400 lb. The water end would have to work against a pressure of 308 lb. per sq.in. before the pressure would equalize, neglecting friction. That would mean pumping against a discharge head of over 711 ft.

"Taking a compound pump with a high-pressure cylinder of 14 in. in diameter, and a water cylinder of 9 in., a 20-in. low-pressure cylinder would probably be added to the steam end, giving an additional steam-piston area of 314 sq.in., which, at a steam pressure of say 50 lb. in the low-pressure cylinder, would mean an added pressure of 15,700 lb. Of course, the steam pressure in actual service is below these figures, the cylinder clearance, condensation, point of cutoff, etc., affecting them."

"Well," I remarked, "your explanation makes the matter plain, but there must be some pretty good-sized pumps to get away with the water from some mines."

"Suppose we take a look into a mine pump room," suggested Hunter, as we neared No. 9 shaft of the Pennsylvania Coal Co. "I think I can get permission to go down."

He did, and we had soon descended to the bottom of the shaft. The mine superintendent's office was visited, and the way it was fitted out was a surprise. The walls, roof and floor were of cement, a neat desk, table, chairs and a rug or two were the furnishings. It was lighted by electricity, and was as sweet and clean as if it had been on the surface, instead of 700 ft. under ground.

After passing through dark, gloomy passages, our way lighted by oil lamps, we finally came to one of the pump rooms, in which were two compound duplex outside-packed plunger pumps, one 16, 30 and 14 by 36 in. in size, the other of the same size but having a 48-in. stroke. (Fig. 1.) Both were run condensing on a 20½-in. vacuum. The condensing water was obtained from the sump and returned to it after passing through the condenser. The walls and floor of the pump room were concrete, and the ceiling natural slate formation.

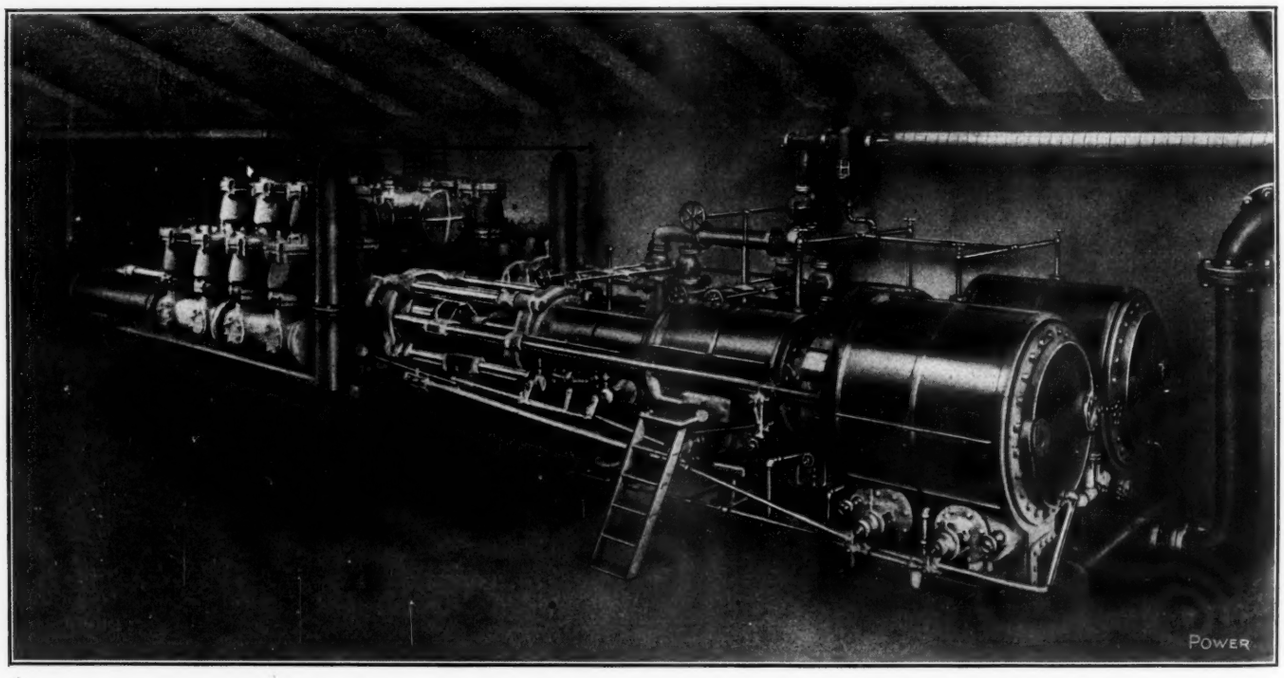


FIG. 2. NEW SCRANTON TRIPLE EXPANSION DUPLEX OUTSIDE END PACKED MINE PLUNGER PUMP

"Where does the steam come from?" I asked, noting the large steam pipe leading into the pump room from a gangway.

"Why, from the boilers, on the surface," answered Hunter. "Although the boilers are sometimes placed underground, near the pump, the general practice is to take steam from a surface boiler plant. The pipes are run down the shaft, and if the pump runs noncondensing, the exhaust steam is carried to the surface, the pipe running in the same shaft. This long exhaust pipe increases the back pressure in the exhaust pipe and

on the pump steam piston. If the exhaust is discharged into the sump, the water is so heated that the temperature of the mine and the humidity are greatly increased, making it difficult to preserve the mine timber. Condensing the steam prevents this trouble, but the heat from the steam pipes cannot be eliminated unless some other power is used to drive the pump."

"What other power could be used?" I asked, as I watched a pump runner fill a lubricator.

"Compressed air is used in a few mines for operating pumps, but as an air-compressing plant is necessary, not more than one in ten mines use it."

"I should think there would be several advantages with the air system, as all leaks would help ventilate the mine, and the heat of the steam pipes would be avoided. Air would cost more than steam, wouldn't it?"

"In large plants, steam would have an advantage. Motor-driven pumps are fast coming into use, however, and electricity is an ideal pump drive. The one drawback is the danger of sparks, in gaseous mines, and the cost of the generating station. But you see, instead of long lines of steam piping, with losses by condensation and back pressure, electric wires, which are easily installed, take their place."

While we were indulging in this conversation we had been making our way to a new pump room where a 16, 25, 42 and 14 by 36-in. standard, duplex, triple-expansion outside-packed pump with pot chamber water ends was being installed. (Fig. 2.)

"How did they ever get this pump down here?" I exclaimed, as I sized up its immensity. "It must weigh 60 or 70 tons."

"It was brought down in parts, one at a time," the foreman of the erecting gang explained. "That pump weighs 85 tons, and has a capacity of 25,000 gal. per min., at a piston speed of 320 ft., and operates against a 500-ft. head."

Seeing that I was interested, he showed me a blueprint of the machine. (Fig. 3.) Continuing, he said, "The water end is completely wood-lined, so that not one particle of cast iron is exposed to the action of the acid mine water. The steam-jacketed cylinder has semi-rotary valves with a special cutoff gear provided with a handwheel so that the point of cutoff can be regulated and adjusted while the pump is in operation. It will run condensing, of course."

"Where is the sump located?" I asked.

"It is not always in the same position in relation to the position of the pump," answered Hunter. "The sump must be placed where conditions in the mine require, which may not be at a convenient point to put the pump. In practice, the pump should not be more than 20 ft. above the bottom of the sump, and the length of the suction should be as short as possible. The main pumping engine is placed as near the shaft as conditions will warrant, so as to reduce the length of piping and the back pressure on the water end."

Split vs. Solid Pulleys

By H. A. Jahnke

A bad mistake made by some engineers, owners and managers of factories and shops is to use solid cast-iron pulleys for all line, jack or countershafting for driving machinery. The advantage of a split pulley over that of a solid pulley is that it can be placed in position without interference with any other part of the shafting equipment, such as removing couplings, hangers and pulleys in order to get the new pulley into place. Especially is the split pulley valuable where an old machine is moved to a new location. Where the pulley driving the machine is of the split type it can easily be removed from one section of shaft and placed on another. A split pulley is also of special value when adding new machinery, because it is not necessary to shut down the plant to cut keyseats in the shaft or to take down a section of shaft to get a pulley in position. The split pulley can be placed on the shaft during the regular noon hour or after closing time in the evening.

Another point in favor of the split pulley is that there are no keyseats or setscrews to mar and spring the shaft; and still another advantage is the ease with which this pulley can be changed to fit the different sizes of shafting through the plant; all that is necessary is to change the bushing for the different diameters of shafting.

Many owners of factories and shops when installing a new machine look over the old pulleys in stock and select one of the required size to drive the machine. The writer had a case of this kind some time ago where a machine was added to the factory equipment and in the stock of old solid cast-iron pulleys, one was found of a size to drive the machine from the line shaft. To get this pulley in position on a section of shaft, a keyseat had to be cut in the shaft and it was decided to do the job on a Sunday. A flange coupling and one solid cast-iron pulley had to be taken off, which made it necessary to take the section of shaft out of its bearings. It took from seven to eight hours to get the coupling and pulley off because it was a very tight fit and rusted on, and it was late in the evening before the job was completed.

It surely would have paid the owner to have left the solid cast-iron pulley in stock or the scrap pile and to have gotten a new split pulley, which could have been placed in position in a short time.

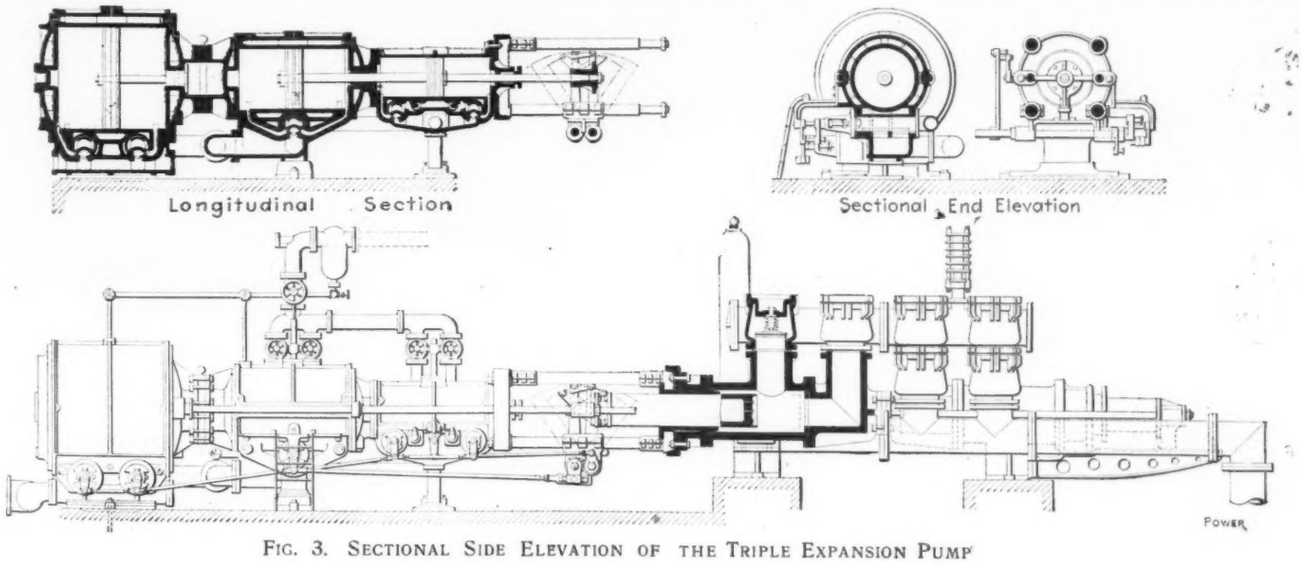


Fig. 3. Sectional Side Elevation of the Triple Expansion Pump

In another instance a machine was moved to a new location. For driving this machine two solid cast-iron pulleys were located on a 2 15/16-in. shaft. To get these pulleys off, this section of shaft had to be disconnected, thereby leaving the other machines which received power from this section idle for several days. Had these two pulleys been of the split type, the machine could have been moved and set up and the two pulleys taken off during the noon hours or after closing time, thus saving the other machines from idleness and loss of time.

Still another instance was that of a solid cast-iron pulley, all the arms of which broke near the hub while running. To get the hub off the shaft in the regular way, a solid cast-iron pulley and one coupling had to be removed. As this would have taken some time, the shafting was shut down long enough to break the rim of the broken pulley to get it off when the shaft was again put in operation. Then a split pulley was ordered of the required size. This pulley was on hand at shutting-down time, when holes were drilled in the hub of the broken pulley with a ratchet, the hub split with a chisel, and the split pulley placed in position. This job was done in a few hours, while if another solid pulley had been used it would have taken at least a day.

Split Pulleys on Countershafting

In most manufacturing plants countershafting with tight and loose pulleys is used for starting and stopping some machines. After the loose pulley has been run for a number of years it becomes worn in the bore of the hub, and the pulley will not run smoothly, causing unnecessary noise. In most cases, to babbitt or bush the hub, the entire countershaft will have to be taken down and the machine shut down for some time, causing a loss of production. There was a case of this kind some time ago where both tight and loose pulleys were of the solid type, and the entire countershaft had to be taken down to get the loose pulley off. Then the pulley was sent to the machine shop to have the bore of the hub bushed. It took several days to get the pulley back again, because the machine shop was rushed with work; all this time the machine had to lie idle.

It is good practice to use pulleys of the split type for a tight and loose pulley system on countershafting or any other shaft where a loose pulley has to be used. They may be of either iron or wood and have the loose pulley provided with an iron sleeve in the bore of the hub. Should this sleeve get worn, the sleeve may be renewed without much labor and expense. If the shaft is worn where the loose pulley has run, the pulleys can be reversed—that is, the tight pulley can be put in the place of the loose pulley.

The writer has made repairs this way without taking down the entire countershaft by first removing the split tight and loose pulleys. Then, should the sleeve in the loose pulley be solid, the hanger and bearing next to the tight or loose pulley is removed, when the shaft is clear at this end and the old sleeve can be taken off and a new sleeve put in its place.

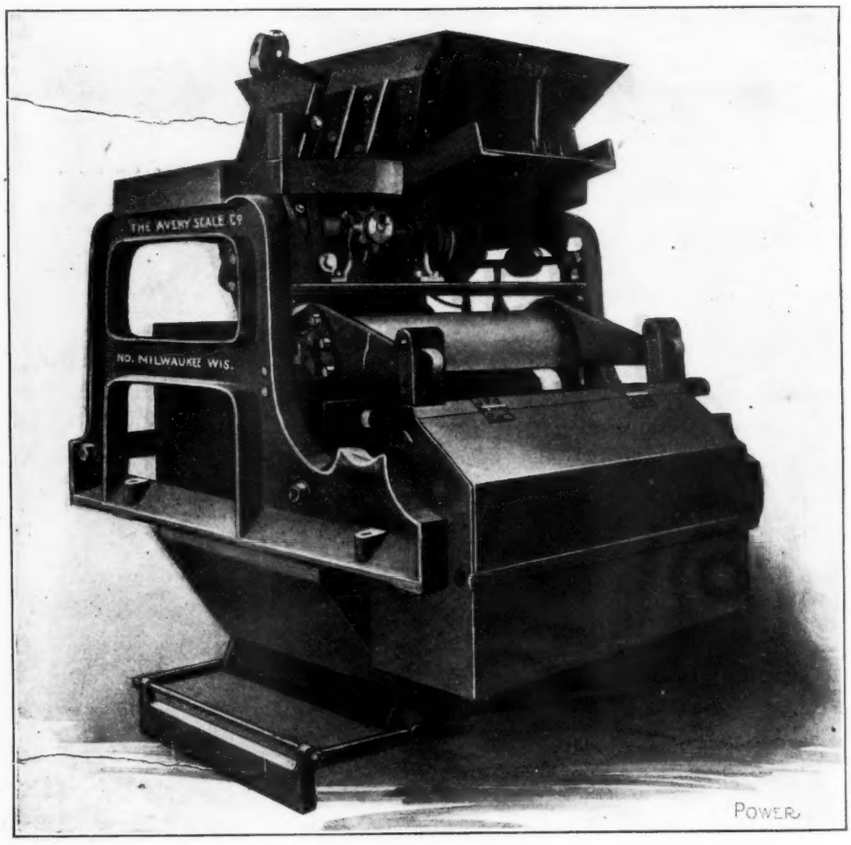
A still better plan is to use a split sleeve for the loose pulley, doing away with taking down any hanger or bearing. Where a split sleeve is used in the loose pulley, repairs can be made on the countershaft without shutting down the machine during working hours. This cannot always be done where solid pulleys are used, as the tight pulley may be a very close fit on the shaft so it will have to be pounded off. If the pulleys are too large to go by some timber or other obstacle, then the only way to get the pulleys off is to take the entire countershaft down.

It is good practice to carry an extra sleeve in stock for all loose pulleys which are split and have an iron sleeve, as an accident is likely to occur at any time to a loose pulley due to the neglect of the machine operator or the regular oiler to oil the pulley properly.

Avery Automatic Coal Scale

One type of automatic coal scale manufactured by the Avery Scale Co., North Milwaukee, Wis., is shown herewith.

This type has a patent soft-coal feeding device and operates on the even-arm beam principle. The beam is double-sided and has six knife edges, two in the center and two at each end. The two center knife edges form the fulcrum of the beam and are supported by steel bearings fixed to the two main frames of the scale. The bottom-discharge weight hopper is suspended from one end of the beam and the weight box, in which standard United States weights are placed, is suspended from the other end. When the weight box and the weight hopper are empty one exactly balances the other. The scale can be tested, without the necessity of checking with another scale, by using known weights.



Avery Automatic Coal Scale

The feeding and the discharging mechanisms are controlled by the weigh beam, although none of their parts is directly connected to the beam which is entirely free to do the weighing at the crucial point. Putting the weights into the weight box tends to depress that end of the beam, but descent is prevented by a projection from the inlet mechanism, the latter being held in a closed position by an ordinary toggle-joint.

To start the machine, it is only necessary to break this toggle-joint when the weights in the box set the inlet mechanism operating. Coal then passes to the weigh hopper, but, before the required amount has descended, the weight of the inlet mechanism is lifted off the weigh beam and supported by a trigger. As soon as the exact weight of coal required is in the hopper that end of the beam descends and pulls aside the trigger which controls the inlet mechanism and by this action the supply of coal is instantly shut off.

Connected to the toggle-joint are two levers which drop when the trigger is pulled aside, and one of them liberates the toggle-joint controlling the weigh hopper, allowing the weighed coal to discharge.

As soon as the contents of the weigh hopper are discharged the balance weight returns the door and the toggle-joint to their original positions. In its travel the projection on one of the toggle-joints hits the same lever that caused the weigh-hopper door to open, which liberates the feeding mechanism so that coal is again delivered to the weigh hopper. While the weigh hopper is filling, the toggle-joint on the hopper is locked, preventing the discharge door from opening and similarly, while the weigh hopper is discharging, the toggle-joint attached to the inlet mechanism prevents coal from being delivered to the hopper.

The feeding mechanism has been especially designed to overcome trouble experienced in getting a machine to handle soft coal containing an appreciable amount of moisture. This feeding device is an oscillating tray moved back and forth by an ordinary crank, and by the shaking motion it automatically clears itself.

The crank is operated by a clutch governed by the weigh beam through the feeding mechanism. The scale is also arranged so that it will automatically regulate itself to the rate at which the coal is taken away. If the machine were feeding mechanical stokers, it would only fill up the spouts which feed the coal to the stokers and then stop working until the coal cleared the outlet door of the weigh hopper.

These machines are made in capacities ranging from 100 to 6000 lb. and are usually made to make one discharge a minute, but the speed can be arranged to accommodate the conditions under which the scale is to work.

Four thousand tons of coal were put into the "Olympic" in 14¼ hours at Southampton recently. This is a record coaling feat for the port and a world's record. Thirty-two gangs of men were employed, an average rate of 288 tons an hour being maintained throughout the night.

An Unusual Boiler Accident*

By Arthur L. Ormay

A rather unusual accident occurred in one of a group of four double-flue boilers (Lancashire type) located in a Viennese plant, the general design of which is shown in the illustration.

The heating surface was 860 sq.ft. and the boiler had a rated working pressure of 180 lb. The boiler was erected and tested in June, 1910, and on Nov. 3, 1911, was examined for corrosion on the shell plate. Shortly before this date, however, the boiler underwent a hydrostatic test previous to applying automatic stokers to the furnaces.

This modification necessitated changing the water gage-glass from a slanting to a vertical position in the center of the front boiler plate.

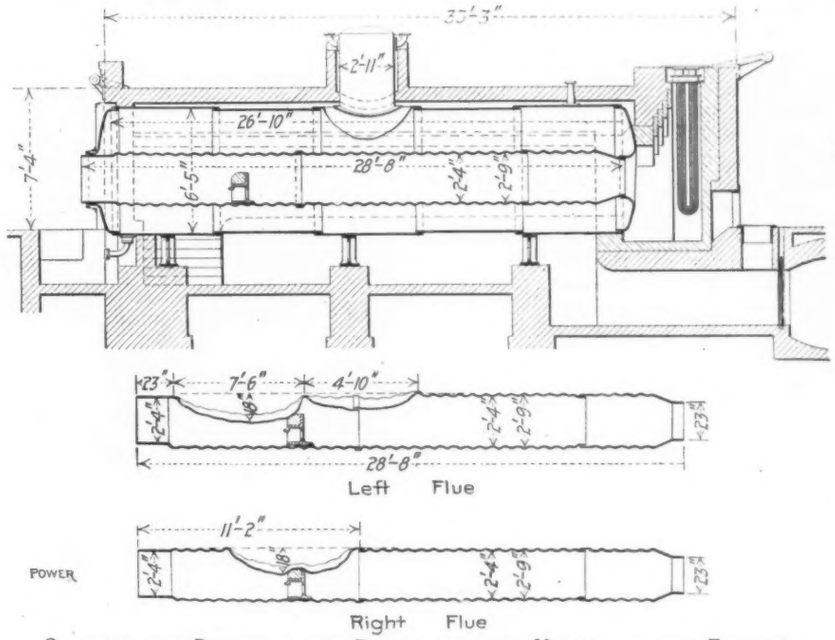
On the afternoon of the day of the accident a fireman noticed steam escaping from the blowoff-pipe pit in front of the boiler, which was covered with an iron plate, and suspected it was due to a leaky gasket in the blowoff line. Later, however, hot water began to run out of the ashpit of the right flue, and a defective flue was suspected. On opening the fire-door the fire was found practically extinguished and the corrugated flue sheet had sagged, as shown. The escape of the hot water soon ceased and steam began to escape from the flue, filling the boiler room, the boiler pressure being 180 lb.

It is believed that, although the water-column connections and feed apparatus were in perfect condition, the boilers had suffered from low water, resulting in the deformation of the flue sheet. The corrugated flues were pressed down to the bridge-wall, causing a sidewise deflection, and in this position the iron bridge-wall support pierced the flue.

Over the upper left edge of the bridge-wall a bulge was formed which showed cracks on the outside flue surface, but not a complete rupture. Similar bulges were noticed in the left flue in the same relative positions, and the bulge was more acute and greater than in the right flue. The middle of the bulge of the right flue coming directly over the bridge-wall led to a greater deformation sidewise which accounts for the rupture of the corrugated flue.

The fireman's negligence in not giving attention to the water level in the boiler was reported to be the cause of the failure.

*Translated from "Zeitschrift der Dampfkesseluntersuchungs- und Versicherungs-Gesellschaft" a. b.



Showing the Design of the Boiler and the Nature of the Failure

Flexitallic Gasket

This gasket is made of layers of waterproofed asbestos and copperized-steel built up at right angles to the line of pressure, in one continuous length, beginning on the inside and ending on the outside. Thus, the gaskets cannot blow out and, owing to its flexibility, the joints are said to be tight regardless of pressure or conditions.

The gasket is also designed to successfully take care of vibration or expansion and contraction. It can be used over and over again, because it is indestructible and does not stick to flanges. It is suitable for superheated steam.

The gasket is manufactured by the Flexitallic Gasket Co., Real Estate Trust Building, Philadelphia, Penn. It is made in all shapes and sizes for use under various conditions.

Steam Power Plant Piping

By William F. Fischer

The merits and demerits of cast-iron pipes and flanges, and riveted steel, brass and copper pipes are set forth. Several tables dealing with the weight and bursting pressure are also given.

Light-weight cast-iron fittings, up to and including 10 in., are recommended for steam pressures up to 50 lb. and water pressures up to 75 lb.; the larger sizes for steam pressures up to 25 lb., and water pressures up to 35 lb.

Standard weight cast-iron fittings are recommended for steam pressures up to 125 lb., and water pressures up to 160 lb. Extra-heavy cast-iron fittings are recommended for steam pressures up to 250 lb. and water pressures up to 300 lb.

Extra-heavy hydraulic fittings are recommended for water pressures from 800 to 2500 lb., depending upon the size and thickness of the metal used.

Pipe fittings are made with a very high factor of safety as they must withstand not only the working pressure for which they are intended, but also the strains set up in the pipe line by water-hammer, vibration, expansion and contraction, weight of piping, settling, etc.

Good gray cast iron has an average ultimate tensile strength per square inch of from 18,000 to 20,000 lb.; gun iron, 30,000 lb.; ferro-steel and semi-steel, 35,000 lb. This metal is tougher and more uniform in strength than cast-iron, or gun iron.

Steel castings should have an average ultimate tensile strength of 60,000 lb. and a minimum elastic limit of 30,000 lb. per sq.in., an elongation of not less than 20 per cent. in 2 in., and a reduction in area of not less than 30 per cent.

Steel fittings and valves are largely used for superheated steam at high pressures and temperatures.

Malleable-iron fittings have an average ultimate tensile strength of 35,000 lb. per sq.in. Such fittings are made in sizes up to 12 in. and are desirable for general service, especially in screwed type.

Brass castings average about 18,000 to 20,000 lb. per sq.in. ultimate tensile strength, and bronze castings about 30,000 lb.

Table 1 gives the average bursting pressure of standard, cast-iron, flanged pipe fittings, designed for 125 lb. working pressure, and Table 2 that of extra-heavy cast-iron and ferro-steel flanged pipe fittings, all designed for 250 lb. working pressure.

Stop valves used in power-plant work may be had in the straight way or globe types with screwed or flanged ends.

The straight way or gate valve offers, when wide open, a straight, unobstructed passage for the fluid through it. Gate valves are made in straight body and angle types with rising or nonrising stem. The angle gate valve is like the straight-body type, except that the body beyond the gate chamber is cast in the form of a 90-deg. elbow. Gate valves are made with single-piece, solid-tapered wedge disks and tapered seats, with double-tapered wedge disks and tapered seats, or with double, parallel disks and parallel seats.

Owing to the rigidity of the solid-wedge gate or disk valve, the gate must be jammed home after it comes in contact with the tapered seats, to make a tight fit; otherwise the valve will leak under pressure. This jamming action has a tendency to score and cut the seats, especially if dirt or grit lodges on them and is ground into the soft metal. When a valve body becomes distorted or strained by the piping settling or by expansion and contraction strains, which tend to spring the valve seats, it is almost impossible to keep the valve tight without first truing up the seats, which necessitates removing the valve from the line.

*TABLE 1. BURSTING PRESSURE STANDARD CAST IRON FLANGED FITTINGS DESIGNED FOR 125 LBS. WORKING PRESSURE

Size Inches	Thickness of Body in Inches	Average Bursting Pressure in pounds per Per Sq.inch	
		Tees	Elbows
6	15/16	1600	2000
8	1	1150	1500
10	1 1/16	1100	1200
12	1 1/8	775	900
14	1 3/16	700	900
16	1 1/4	750	850

*Crane Co.

*TABLE 2. BURSTING PRESSURE EXTRA HEAVY FLANGED FITTINGS DESIGNED FOR 250 LBS. WORKING PRESSURE

Size Inches	Thickness of Body in Inches	Average Bursting Pressure in Pounds per Square Inch			
		Extra Heavy Cast Iron		Extra Heavy Ferro-Steel	
		Tees	Elbows	Tees	Elbows
6	1 1/4	1687	2275	2733	3266
8	1 3/8	1350	1625	2250	2725
10	1 1/2	1306	1541	2160	2350
12	1	1380	1275	2033	2133
14	1 1/8	1100	1075	1825	1700
16	1 3/16	1025	1250	1700	2100
18	1 1/4	600		1450	
20	1 5/16	750		1275	
24	1 1/2	700		1300	

*Crane Co.

The double-disk gate valve is flexible, as the disks readily adjust themselves to any inequalities or distortion of the seat rings. Should the valve body become distorted and throw the seat rings out of alignment the double disks when closing will rock into position for perfect seating.

Gate valves over 6 in. in diameter should have bypass connections to equalize the pressure on both sides of the gate, and also permit steam to be admitted slowly into the cold end of the line, warming it up gradually before opening the main valve. This prevents water-hammer in the main and tends to distribute the expansion strains more uniformly throughout the piping system.

Globe Valves

A globe valve is divided by an L-shaped partition, which offers considerable resistance to the fluid flow through the valve and over the partition, making two turns at nearly right angles.

The greatest strain on the threaded stem is when screwing the disk down hard against the seat, but nearly always the stem could be twisted off before the threads would fail.

Globe valves in horizontal steam lines should have their stems horizontal to prevent condensation water flooding the line and causing water-hammer. With the valve stem vertical, the condensation will fill the pipe about half full of water before it begins to flow over the valve seat and through the valve.

Globe valves are seldom used as stop valves on water or steam mains because of the excessive friction they create. They are chiefly used as throttle valves, placed near the machines they control. A gate valve is unsuitable as a throttle valve as the disk tends to chatter when partly open; it will not regulate the supply as well as a globe valve, which can be opened full, or closed much quicker.

All screwed fittings, valves, or flanges up to and including 12 in. should be tapped to conform to the Briggs or U. S. standard pipe gage as adopted by all the leading manufacturers of piping materials in the United States. When properly machined, and made up, a screwed pipe joint should be steam- or air-tight against any pressure the pipe will safely withstand.

To avoid difficulty and delay in erection, new fittings and valves to replace old ones should have exactly the same dimensions and drilling as those they are to replace; a point frequently overlooked by the man who places the order.

Flange joints are advisable on all high-pressure lines above 2 in. The first cost for flanged valves and fittings is slightly greater than for screwed ends, but the many advantages warrant the additional cost.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

An Old Motor

By C. V. Hull

A short time ago a large manufacturing concern purchased a number of 220- and 250-volt motors from an electrical power company. These were direct-current motors which had been replaced by alternating-current equipment. Most of the direct-current machines were modern, but among them was a 10-kw. Edison motor built by the General Electric Co. under patents issued in 1882; the serial number is 428.

Fig. 1 shows the switch side and gives a good idea of the construction. This bipolar arrangement is similar to the first Edison dynamo, which was exhibited as a relic at the Buffalo Exposition. The armature is surface wound, and instead of the modern soldered connections, the leads are fastened to the commutator bars by screws. The brush rigging is evidently of later date as carbon brushes

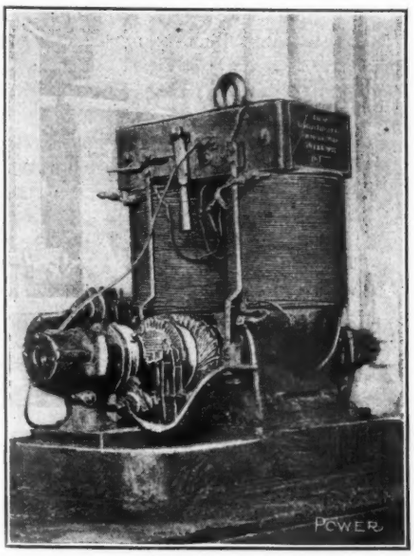


Fig. 1. Old Bipolar Motor

are used, with holders having adjustable flat springs.

The sleeve bearings are of high-grade bronze and each is oiled by two rings. As compared with later 10-kw. motors, the large size of the bearings is noticeable.

The disconnected ends of the series windings are easily seen. These were fitted with clips which were hand-made, judging, at least, by their appearance. The shunt connections may be seen on the side of the upper part of the frame, as well as the corded insulation about the field winding and some of the rubber tubing on the ends of the series winding.

On the side of the frame is the switch used to short-circuit the original starting rheostat, which was a cube-shaped affair with a simple contact handle moving over the contacts arranged in a circle,

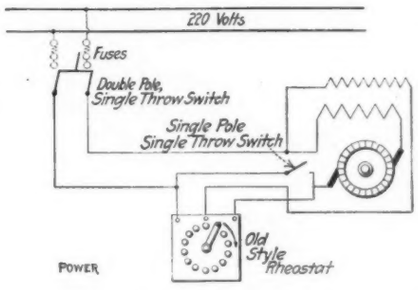


Fig. 2. Line Connections

similar to a field rheostat construction. When starting up, the resistance was cut out by moving the handle of the rheostat around the circular row of contacts. The switch on the side of the motor frame was then closed and the handle of the rheostat returned to its original position for starting; see Fig. 2. In case the operator forgot to bring this handle back, the fuses would blow when the line switch was closed to start the motor again. Or, if the operator failed to pull out the switch on the frame, fuses were liable to be blown when starting again. It is apparent that the whole operation of starting was nonautomatic in every step.

Owing to a shortage of motors when this old machine was received, it was used for some time on a hoist, raising a heavy weight for breaking scrap iron. A modern magnetic release rheostat was used. The series windings were not connected as the motor ran well with only the shunt field in service.

A few months ago, however, the motor was taken out of service because the field was so strong that pieces of iron, broken off by the blows of the weight, sifted through cracks in the roof of the motor shelter, and were drawn into the space between the pole pieces and the armature. These chips cut off so many wires on the armature that another motor of modern construction was installed in its place.

Selecting Faulty Cables

At the recent convention of the American Electric Railway Engineering Association, the committee on power generation submitted a report upon "Methods of Selecting Faulty High-Tension Cables at the Power House."

To ascertain present practice in this line the committee first sent letters to a number of companies operating large plants and the replies indicated that many had not taken advantage of developments in the art and therefore employed no satisfactory method of selection. Others employed methods satisfactory to their own local conditions, but the replies in general indicated the need for further development.

The report goes on to say that electrostatic ground detectors will often indicate a weakening of the insulation before the current increases to a destructive value, but they do not indicate nor select the faulty cable and their use is limited to systems operated without the grounded neutral.

Torchio-Varley System

The Torchio-Varley system, based on the relative phase insulation resistance to ground, will indicate the feeder at fault, if the feeders are not in parallel, in which case it will indicate only the group to which the faulty cable belongs. Moreover, this system can be applied only to underground cables and cannot be used with a grounded neutral. It has been successful on high-tension underground systems of 6600 volts where the high-tension feeders are not operated in parallel.

Relays

Overload relays are in general use for both overhead and underground feeders. Some of these when properly set are fairly successful in selecting a faulty cable where a ground exists with the neutral of the system grounded, but where there is a "short" between phases, these relays are often unsatisfactory and sometimes cannot be depended on for actual selection.

Where feeders are operated in parallel, either with or without grounded neutral, it would seem that the faulty cable could be selected by means of inverse time element overload relays, having characteristics between the ordinary inverse time limit and definite time-limit relays,

on the generator end of the cables and satisfactory reverse-current relays on the receiving end. Alternating-current reverse-current relays have in general been unsatisfactory, being inoperative on low power factor loads, and very likely to trip the breaker on direct overloads. Reverse-current relays to be satisfactory should operate practically instantaneously on a reversal of power only, not on overload, and should not operate on slight reversals, such as might be occasioned by throwing a rotary converter on the line when slightly out of phase.

If such a reverse-current relay did not actually select the faulty cable it should at least indicate that it has operated on a reversal of power.

Mertz-Price System

The Mertz-Price system and its modifications are based on balancing the currents at the two ends of the apparatus to be protected, and the system as developed cannot be used without pilot wires—two wires per cable for magnetic balance and one wire per phase per cable for balancing the electromotive force. On a large system the cost of pilot wires is excessive.

This scheme, however, will select and isolate the faulty cable under practically all conditions of service. It is especially suited to the selection of faulty high-tension tie-line cables between two generating stations or between two substations, each supplied directly from a common source. This system has been in use in England and on the Continent for more than two years.

Mr. Stott's Suggestion

H. G. Stott offered a suggestion for overcoming these difficulties which appears to be quick and at moderate cost applicable to practically all operating conditions. His scheme is to install, in the main station having double busbars, a three-phase transformer with a 1-to-1 ratio having high resistance and poor regulation and rated somewhat higher than the charging capacity of the longest cable of the system; under these conditions the short-circuited current would be only slightly in excess of its capacity.

To select the cable at fault, when all or some of the switches have gone out, it is necessary only to connect one end of this transformer to the high-tension busbar in service and then connect, one at a time, the doubtful cables to the high-tension busbar which is energized through this transformer. This applies full voltage to all phases of the cable simultaneously and its condition will be indicated by ammeters connected in the circuit. Each cable after being tested and found satisfactory can be connected to the busbar supplying normal service. Such a test can be applied by the switchboard operator without leaving his station and requires but a few minutes to complete with a minimum service interruption.

Largest Direct Current Generators

The new plant of the Southern Aluminum Co., now under construction, at Whitney, N. C., will contain seven vertical waterwheel-type electric generators, representing units of the largest capacity ever built for generating direct current. They will be of G. E. make, and each machine will have a rating of 5000 kw., delivering 20,000 amperes at 250 volts and operating at a speed of 170 r.p.m. Two smaller direct-current generators of the same type, rated at 2500 kw. when running at 300 r.p.m., and two 1250-kv.-a. alternators, having a speed of 514 r.p.m., will be included in the equipment.

The machines will be directly connected to vertical shafts of S. Morgan Smith turbines by forged-steel flanged couplings. Each 5000-kw. generator will weigh about 150 tons, measure 22 ft. in diameter and extend 13 ft. above the floor level. The entire rotating element of the generators will be supported from an overhead thrust bearing. Although the normal speed will be 170 r.p.m., the generators will be designed with provision for a safety runaway speed of 75 per cent. above normal. The wheel governors will have remote electric control for both hand and automatic operation.

CORRESPONDENCE

Blown Fuse

In a large department store where a refrigeration system is employed, there is a 5-hp., 550-volt, three-phase motor belted to a centrifugal pump for the brine circulation. One morning the motor refused to start, but when the belt was taken off and the motor turned by hand it got up to speed, but would not carry the load; moreover, the solenoid on the starting box for the automatic cutout was dead. The electrician was directed to take the starting box apart, but after working 5 hr. the trouble still remained. The engineer then blamed the motor, but this was new.

Finally it was suggested that the voltage might not be the same on all three phases. The illustration shows the transformer connections to the motor. The voltage from *A* to *B* measured 550 volts, from *B* to *C*, 275 and not any from *A* to *C*. One of the primary fuses was blown.

Can any readers tell which fuse blew on the primary circuit?

J. G. Koppel.

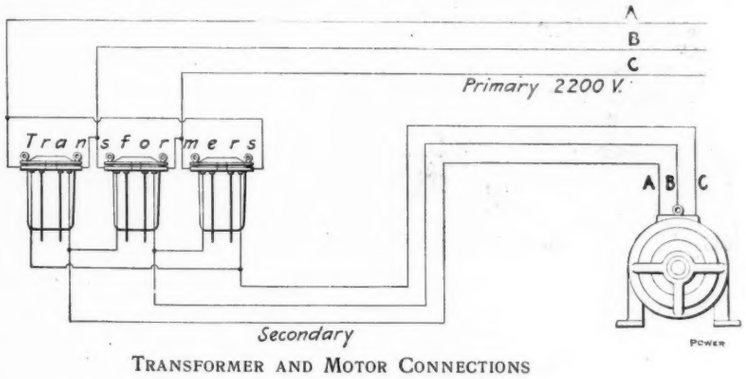
Montreal, Que., Canada.

Neutral Brush Position on Interpole Machines

The method of locating the neutral brush position described by J. S. Kinney in the Oct. 15 issue is correct, and will give the desired result provided residual magnetism in the main magnet cores can be kept out of existence during the test. Unless the entire magnet is of laminated construction, however, this is difficult to do and entails a tedious repetition of "killings."

The neutral position can be located more quickly and with equal certainty by the following procedure:

Drive the armature at full speed and excite the main field winding from some separate source until a moderate voltage—say one-fourth the normal voltage of the machine—is obtained at the brushes, with the interpole winding dead. Then excite the interpole winding fully, from a separate source, and note whether the voltage at the brushes increases or decreases. If it does either, the brushes should be adjusted to a point where closing the circuit of the interpole winding makes no difference in the brush voltage. The speed must be kept the same when the interpoles are active as when they are dead, and if this cannot be done, then correction must be made in the voltage readings by dividing the voltage by the speed each time the field excitation is changed. The quotient of volts divided by revolutions per minute must be the same with and without interpole excitation.



Transformer and Motor Connections

Cecil P. Poole.

Atlanta, Ga.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

The Junkers Engine—III

By F. E. Junge

Conditions Influencing Operation

To form an opinion of the Junkers engine it is essential to discuss those features of operation and construction, upon which the merits of large oil engines are preëminently dependent. These are: conditions influencing the cycle of operation, action of forces, frame and support, power-transmitting mechanism, reliability, overhauling, erection, dismantling and general economic aspects. In the following discussion in which the views of Professor Junkers are given in support of his claims, the normal single-acting Diesel two-stroke-cycle type of engine has been referred to for comparison.

Combustion Chamber

In Fig. 13 the Junkers engine is compared with a single-acting two-stroke-cycle valve engine, the comparative simplicity of the combustion space of the former being apparent. A better idea of the complexity of the cylinder castings for Diesel engines of the double-acting two-stroke-cycle type, which must be used for large work, is conveyed by Figs. 14 to 16, of which Fig. 14 is a section through the combustion space of a Junkers engine, Fig. 15 a section through the upper cylinder cover, and Fig. 16 the lower dead space of a Diesel engine.

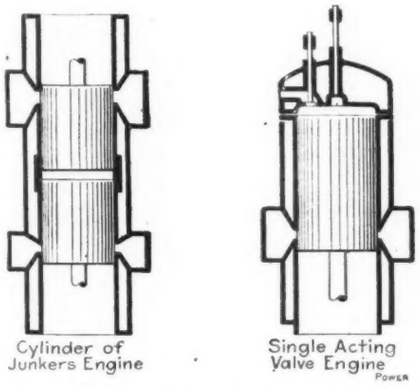


Fig. 13. Junkers Engine Compared with Single-acting Valve Engine

The extreme simplicity of the Junkers engine, as shown, admits of the complete control of combustion with large diameters, and has a favorable bearing on the heat transmission. A result of this is the possibility of running the engine at slow speeds, thus insuring flexibility.

In contrast to the Junkers engine the combustion chamber of the Diesel engine is most intricate, as can be inferred from the illustration. In this case the control over combustion becomes difficult with large diameters, the heat transmission is influenced to an unfavorable extent, and permanent control over the high temperatures with large diameters is out of question. As a result of this the fracture of cylinder heads is not an unusual occurrence, and slow running is unsatisfactory in large Diesel engines.

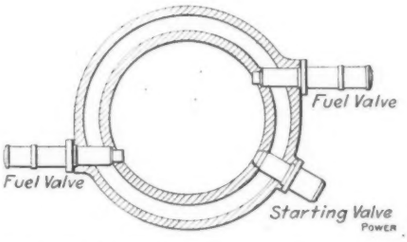


Fig. 14. Section through Combustion Space of Junkers Engine

Heat Transmission to Cylinder Walls

The work lost by the communication of heat to the cylinder walls does not so much depend upon the aggregate value of this heat dissipation, but rather on the nature of its distribution over the stroke of the piston. For the heat lost during combustion and during the early part of the expansion stroke a corresponding amount of power becomes unavailable for useful work. The heat lost toward the end of the expansion stroke, however, has already expended its expansive power available for performing useful work; hence does not impair the fuel consumption. As far as the utilization of the initial heat within the cylinder is concerned, it is immaterial whether the last quantity is communicated to the cylinder walls or leaves with the exhaust. Therefore, it is necessary to keep the ratio of area to volume of combustion space as small as possible. This is necessary also for reasons quite apart from the foregoing, since during combustion the dissipation of heat is greatest, the pressure and temperature attaining their highest values.

The most practical way of procuring a small area of the combustion chamber is to decide upon a large ratio of piston stroke to diameter of piston. In the Junkers engine such a ratio is the natural result of its peculiar arrangement. It therefore differs from other engines in possessing the smallest heat dissipation during combustion and in this respect is thermally superior to others. The practical tests confirm this theoretical consideration. Owing to the favorable configuration of the surface of the combustion chamber the final compression temperature required for the ignition of the fuel is positively attained at a comparatively low piston speed. Therefore the speed of the Junkers engine can be considerably reduced without fear of a failing ignition.

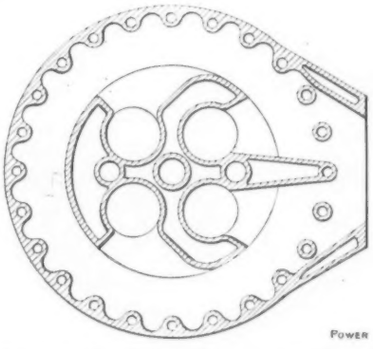


Fig. 15. Section through Upper Cylinder Cover of Diesel Engine

Scavenging Features

The success of a two-stroke-cycle engine is largely dependent upon its scavenging features. Complete scavenging (cool and pure charge) is not only a desideratum with this type, but its realization is of vital importance; for on the scavenging depend the absolute command of positive ignition, an economical,

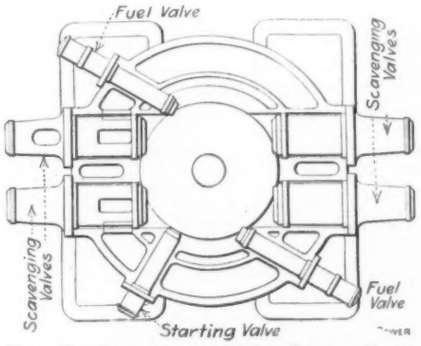


Fig. 16. Section through Lower Dead Space of a Double-acting Two-stroke-cycle Diesel Engine

soot-free combustion and the output of the engine. Difficulty in attaining perfect scavenging in the two-stroke-cycle engine is due to the fact that the events for which two full strokes are provided in the four-stroke-cycle engine, namely, the exhaust and the suction strokes have to be effected during part of one stroke. If, notwithstanding the short time available a pure and cold charge is to be procured the following conditions must be fulfilled: A long cylinder of as small diameter as possible; a perfectly smooth scavenging space devoid of all reëntering or protruding parts, which are liable to retain burnt gases; exhaust and scavenging ports of ample size; precise and positive governing and rapid opening of the exhaust and the scavenging ports; and ports at opposite ends of the cylinder calls for the use of two pistons as governing elements. This disposition is by no means incidental, but is the outcome of systematic experimental research, extending over many years. The line of thought underlying these researches is shortly characterized in the following:

1. Complete expulsion of the products of combustion at the end of the power stroke is essential to the life of every engine of this type, and dependent upon this is the realization of positive ignition, of a perfect, soot-free combustion, of low-grade fuels, and of a high mean indicated pressure.

2. To insure rapid exit of the waste gases with a small consumption of energy during the short time available, large exhaust-slot areas must be provided. Furthermore, in order that these large slot areas may be precisely and rapidly uncovered and covered, gas-tight, close-fitting, and rapidly acting governing elements are necessary. The best way to attain large port areas is, of course, to arrange the port openings along the whole circumference of the cylinder, and the governing element satisfying these conditions in the most perfect manner is, obviously, the piston itself.

3. The same considerations apply to the admittance of scavenging air as to the expulsion of the exhaust gases. Hence, the arrangement of the ports and the choice of the governing elements is the same, essentially, as in the first case, namely, admission slots disposed over the whole circumference of the cylinder and the use of the piston for governing.

4. To avoid a mixing of the scavenging air and the burnt gases both must be conducted in the same direction of flow, that is, the exhaust ports must be at one end, and the inlet ports at the other.

5. The additional features, such as the simple and reliable combustion chamber of relatively small heat-transmitting surface, the high aggregate piston speed, the balance of reciprocating parts and the absence of all delicate parts exposed to high temperatures, all guarantee a working efficiency far superior than the seemingly complicated method of inter-connecting the pistons appear to guarantee.

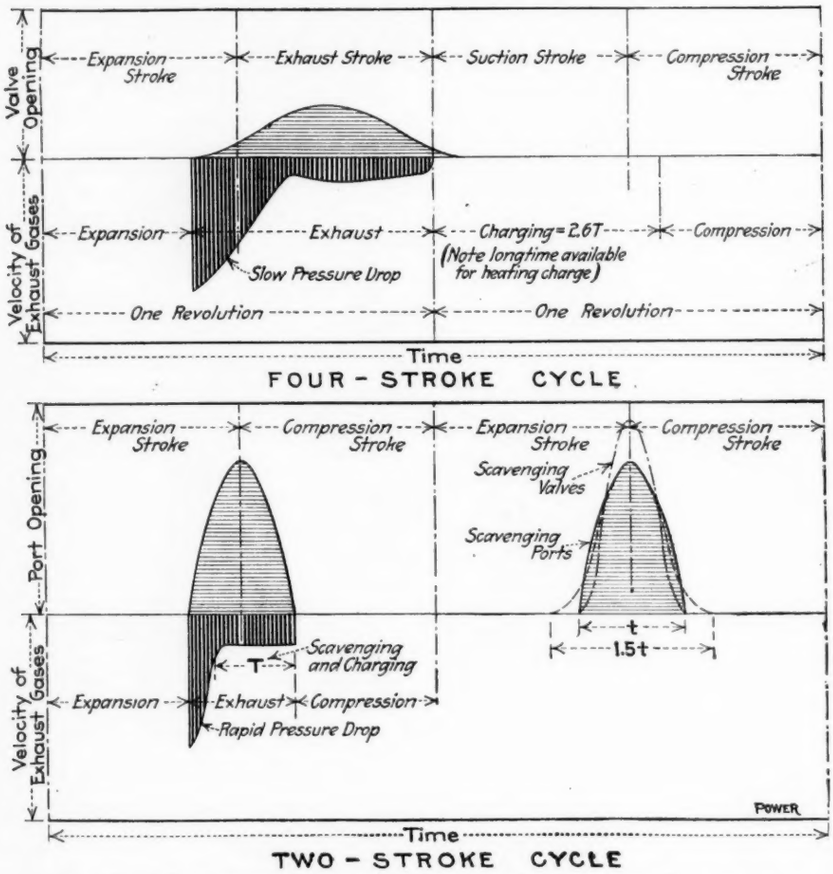


FIG. 5. COMPARISON OF JUNKERS TWO-STROKE-CYCLE ENGINE WITH A FOUR-STROKE-CYCLE ENGINE

Another point to be considered is that the velocity of the air has a great influence on the effectiveness of scavenging. The velocity conditions during scavenging of two- and four-stroke-cycle engines have often been the subject of comparison, and, to some extent, the unfavorable criticism advanced against the two-cycle engine has been justified. The diagram shown in Fig. 5, in which the Junkers engine is graphically compared with a four-stroke-cycle engine of equal cylinder volume, shows that in the Junkers engine these conditions are decidedly favorable. The net port openings of the valves are plotted as ordinates against the time elapsing as scavenging progresses. Below the base line, but in the same direction, are plotted the corresponding velocities of the exhaust gases. Here the difference of time, and, therefore, of pressure drop available for the escape of the burnt gases is plainly shown. It requires much more time in the valve-governed engine and, moreover, is responsible for much greater throttling and wire-drawing losses in the valve seats.

The unfavorable conditions resulting from the necessity of accelerating and retarding the valves used as governing elements are also existent in the two-stroke-cycle valve engine. The diagram also shows the necessary time of opening and the net opening area required by the two-stroke-cycle valve engine, if the same favorable conditions of operation are to be attained which are inherent in the Junkers engine. The requirements are either 1.5 times the time with equal area, or 1.3 times the area for equal times.

PREHEATING OF AIR BY SCAVENGING VALVES

It is often maintained that the scavenging valves of valve-governed oil engines present no difficulty in actual running service. This opinion is based upon the supposed cooling of the valves by the scavenging air. Should this cooling actually take place, there could only be an

omission of valves or other inlet devices for admitting scavenging air in the combustion chamber. All of these conditions are met by the Junkers engine.

At the end of the expansion stroke when the pistons have about reached the outer dead-center position, the products of combustion leave by a row of ports at the one end, extending over the whole circumference of the cylinder. Simultaneously the scavenging air enters through corresponding ports at the other end, expelling the waste gases in the direction of their flow. The characteristic arrangement of the exhaust and the scavenging

illusory advantage attending it. For, taking it for granted that the scavenging air cools the valves, a heating of the air becomes inevitable. This, however, would not be keeping within the fundamental conditions to be met in oil engines, namely, employing a pure and cold charge.

On the other hand, the scavenging air can only enter without being heated, if it does not cool the scavenging valves. In this case the latter are exposed to the deteriorating effects of intense heat. One of the above contentions must surely be correct. Probably what actually happens is that the scavenging valves are not cooled by the scavenging air to an extent that would conform with absolute reliability of operation, whereas the air is heated to a degree making it impossible for a cold charge to be attained. Assuming that only 5 per cent. of the total heat of combustion is imparted to the air charge, the latter will sustain a rise of temperature of from 80 to 100 deg. C. This would correspond to a diminution in the weight of the charge of from 20 to 25 per cent. The mean pressure of the working diagram will show a corresponding decline, while the temperatures and pressures during combustion will not be lower.

When it is considered that large oil engines of the double-acting two-stroke-cycle type, in addition to the two stuffing-boxes, have from four to six valves in each cylinder head, making eight or twelve valves per cylinder—all of which, except the starting valves, are constantly operating under severe temperature and pressure conditions; and that where used in marine work, repairs on shipboard are difficult to execute, it must be admitted that the simplicity of the Junkers cylinder is not too dearly bought by mechanical complications outside.

Producing Gasoline from Natural Gas

By Frank P. Peterson

In 1911 the world's yield of crude petroleum is believed to have been about 520,696,316 bbl.. While difficult to say just how this was split up into the various commercial forms, it is safe to say that not less than 10 per cent., or over 32,000,000 bbl., was used in the form of gasoline. This is notable in contrast to the fact that 20 years ago there was no appreciable demand for gasoline.

An important step in the production of gasoline has materialized during the past 2½ years in the form of stripping waste gases of suspended heavy hydrocarbon vapors and using these condensates as gasoline.

Theoretically, the process of recovery is very simple, namely, the application of pressure and cooling of the gas, provision being made for separating the condensates by precipitation under pressure.

Nearly all the oil wells yield some gas; many yield great volumes while others yield gas only from the strata in which the oil is produced. Again, some yield one gas from their oil strata and another gas from other strata through which the well passes and which is not "cased off."

The gases which issue from "dry" or nonoil-producing strata are often largely pure methane (marsh gas, CH_4), which has a critical temperature of 115 degrees F., and will not condense at any pressure above that temperature.

The gases which reside in the strata along with the oil, however, are in contact with the oil in a finely divided state in the interstices of the sand. There is every opportunity for the methane gas, when issuing from the strata at low pressure along with the oil to pick up and carry in suspension any vaporous oil. Further than this, it is now known that the whole family of saturated hydrocarbons are found together right through the series from CH_4 to a heavy wax structure. This complicates matters, for there are many gases that have and many that have not sufficient suspended heavy compounds to yield paying quantities of gasoline concensates. Hexane (C_6 H_{14}), petane (C_5 H_{12}) and butane (C_4 H_{10}) are the factors which, when present in sufficient quantity, warrant reduction to a liquid state for market. Hence, the prevalence of these condensible constituents must be determined before attempting to compress the gas for their recovery.

One of the first steps is to find the specific gravity of the gas, although this cannot be depended upon entirely. For instance, family A, from one well or group of wells might consist of 10 per cent. methane, 30 per cent. ethane, 30 per cent. propane and 30 per cent. butane. The specific gravity would be about 1.43 (air = 1), and nothing could be produced from it marketable as gasoline.

Family B, from another well or group of wells might consist of 60 per cent. methane, 5 per cent. ethane, 5 per cent. propane, 5 per cent. butane, 10 per cent. pentane and 15 per cent. hexane, in which case its specific gravity would be 1.26 and the 25 per cent. comprising the two heaviest constituents would yield a gasoline condensate, marketable as gasoline of at least 9 gal. per 1000 cu.ft. of gas.

The condensates yielded by the different gases are classified commercially into two general groups: natural gas gasoline and gasol. The first is the unrefined bulk of condensate as it is recovered from the gas and the second is the refined compounds derived by splitting the condensates into groups for different uses.

John Lathrop Gray secured the first broad patents relating to the production of gasoline from natural gas, and the writer, perceiving the need for further refinements, deviated from Grays' constant-pressure, constant-volume method by breaking the operation into steps for the purpose of drawing off fractions differing in specific gravity and boiling points. More recently, however, Dr. Snelling has added what appears to be the final touch of refinement which respects both the critical pressure and temperature characteristics of different compounds and enables the greatest nicety to be realized in the fractionation of the complex gaseous compounds into their several liquid states. It is needless to add that the gasol fractions must be retained and handled under restraint of considerable pressure when they approximate propane and the lighter compounds.

An important phase of the recovery of gasoline from natural gas is that separation is effected under physical conditions maintaining a close equilibrium between the liquid and the gaseous states. Because of its lightness as compared to the mediums ordinarily handled by baffling and trapping, much difficulty has been experienced in eliminating uncertainties in the operations; hence, a vast amount of "cut and try" application.

Physically the product in appearance is white. It carries, usually, a very small (negligible) percentage of heavier oils, sometimes lubricant from the compressor cylinders. In time it evaporates to complete dryness comparable to and usually quicker than a refined oil product of equal heaviness. Its specific gravity varies widely, in different regions and with different pressures applied to obtain it, ranging from 0.625 to 0.71 (water = 1), or from 96 to 68 deg. Baumé.

As a fuel for gasoline motors its carburetting qualities are excellent. Consequently, the impression has become more or less general that its power value is much greater than ordinary refined gasoline. This is not true, except in the sense as the hydrogen ratio of a fuel increases, so does its gross fuel value.

Refined stocks, because much less volatile, can be stored without loss, while the new product cannot, even in winter, be stored in open tanks without loss. As fuel for light gravity gas lighting machines it is good, but its most fitting place seems to be in mixture with the refiners' low gravity gasoline or naphtha fractions whereby a motor fuel of maximum power and the best carburetting characteristics may be had.

Many instances have already occurred in which the abandonment of a few small oil wells in oil fields has been saved by the installation of equipment to recover gasoline from their heretofore wasted gases. And it is not unusual for such wells to yield a greater amount of gasoline condensates than they do of crude oil. And as the condensates have a value at the well of about twice that of the oil, it can readily be seen how great a boon it is to the small oil operator whose revenue cannot be maintained sufficient for livelihood from the oil alone. The present production is about 2500 gal. per day.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Raw Water Can Ice Making Systems

By Samuel Sydney

Distillation of the water for freezing in can ice-making plants has generally been considered essential to secure clear crystal ice that would equal in appearance the best natural product. Recently a number of methods of making clear ice in cans without prior distillation of the water have been tried out, and most of them with a fair degree of success. Clear plate ice has always been produced without distillation, but there are numerous objections to the plate system, and the fact that about 90 per cent. of all the ice-making plants installed are can plants indicates the superiority, or at least the belief in the superior fitness of the can system.

Raw-water ice-making plants in use at the present time may be broadly divided into two general classes: those employing stationary ice cans, from which the ice is lifted out of the can, when the freezing is completed, and those utilizing the ordinary removable ice cans used in making distilled water ice. Of the first class there are two distinctive types: the Jewell system, with a "nonfreezing zone" at the bottom of the can, and the Pownall system with a siphon-connected precipitating tank adjoining the freezing tank.

Raw-water freezing systems of the ordinary can type have been in use for many years with more or less success, but only within the last year or two have they been so perfected as to appeal to prospective ice manufacturers sufficiently to induce any considerable number of installations. During 1912, however, a score or more of such plants have been installed and appear to be operating successfully.

Experiments in freezing raw water in cans by agitation with air were made years ago, there being records of successful experiments in Geneva, Switzerland, in 1877, in England in 1879 and in Brooklyn, N. Y., in 1882. Victor H. Becker made clear raw-water ice with an air blast in the cans in this country in 1874, antedating them all. But these remained as experiments and were soon abandoned for the distillation process.

The early experimenters who succeeded and are still operating on their plans are J. E. Simon, of Louisville, Ky., who secured a patent on his system in 1898 and who operates a 100-ton raw-water ice plant in Louisville, and E. J. Ulrich, of Colorado Springs, Colo., whose patents were issued in 1901 and who operates plants in Colorado Springs and in Salt Lake City.

The extra labor required in the tank room of a raw-water plant adds to the cost from 4 to 9c. per ton of ice made as compared with distilled water ice, but the saving of labor and fuel at the steam end of the plant not only counter-balances this extra tank-room labor cost, but considering also the saving in space requirement and in original investment, raw-water ice is actually being made at from 10 to 20c. per ton less than in distilled-water plants of equal capacity.

Simon System

In the Simon system previously referred to, air pipes are laid in the partitions of the freezing tank, depressed in alternate rows, with air cocks attached facing both ways. The air cocks are screwed into the bottom of the air line, and each has an orifice $\frac{1}{16}$ to $\frac{3}{32}$ in. in diameter. A flexible connection is made between these air cocks and an air tube extending to within about 6 in. of the bottom of a 300-lb. can. This depending tube is made double, consisting of a brass pipe with an ½-in. bore within which is another pipe with an ⅛-in. bore. The outer pipe is closed around the inner pipe with a ½-in. bore within which is another pipe with a ⅛-in. bore. The pipes. As soon as the ice can is filled with cold water from a well or city main one of these depending pipes is hung in the water at the center of the can and sustained by a tube holder held to the eye of the can by a spring. Air pressure at 1½ to 2 lb. is then turned on, keeping the water in constant agitation until all of it except about two quarts at the center of the can is frozen. The air tube is then withdrawn, the water sucked out and distilled water placed in the pocket and allowed to freeze. A clear crystal cake of ice with scarcely any visible core results. It should be added that the air before it is admitted to the main air pipes on the tank frame is passed through a dehumidifier which removes excess moisture in the air and prevents danger of snow or frost forming in the depending tube interfering with the free flow of the air to the water in the can.

Ulrich System

In this system each can is made with a pipe running down the outside of the can and across the bottom, entering through a small expansion chamber and check valve at the middle of the bottom of the ice can. For the air supply an air header, with suitable laterals is laid in the framework of the ice tank, or under it. The laterals are connected with the pipe on the outside of the ice can by means of a flexible hose connection. Inserted in the air laterals are ¼-in. valves for each can, to control the air supply. In the early experiments with this system the air pipe passed through a reservoir at the bottom of the can, but it was found impossible to prevent freezing of the orifice in the air pipe and the reservoir plan was abandoned. Instead, the air after leaving the air compressor is cooled by passing through water-covered coils and then through an air drier. After that no difficulty was experienced from freezing of the air pipe at the pressure carried about 10 lb. The ice is pulled and harvested as in the ordinary distilled-water can plants.

Ashton's Modification

A modification of the two preceding systems is that in use in a large ice factory in St. Louis, Mo., devised by its superintendent, W. A. Ashton. In this plant the air is conveyed through a header along one side of the tank with laterals branching off across the top of the tank between each two rows of cans. The laterals are laid in the tank frame and communicate by means of a hose connection with the separate galvanized-iron air pipes provided for each can. A valve on the lateral controls the air supply for each row of cans. The air pipe for insertion in the ice can is provided with a short horizontal piece at the top for hose attachment and at the bottom has a small piece of flexible rubber tubing with an opening of only $\frac{1}{32}$ in. The action of the air keeps the flexible rubber end in constant motion which aids in agitation of the water and tends to prevent the possible closing of the orifice by frost. In operation the cans are filled with city water by means of a special can filler, the air pipe, which is supported at the top with a small cleat, is dropped in, and air from the compressor at about 8 lb. pressure is turned on. The air, however, is first passed through a copper-tube cooler and its temperature reduced with water, after which it is passed through an air drier and deprived of its excess moisture. After about 85 per cent. of the water in the can is frozen the air pipe is with-

drawn, the water remaining in the can is sucked out by means of a vacuum pump and distilled water run in through a hose to take its place.

Some Chicago Installations

An improvement on the St. Louis method is that employed at the Lincoln Ice Co.'s plant in Chicago. Here the air mains and laterals are laid, as in the St. Louis plant, in the ice-tank frame, but between each two rows of cans brass castings with a reamed socket on each side are fastened into the air laterals. A tee pipe is provided for each can, one end of the tee being beveled to fit snugly into the reamed opening of the brass casting. The other end of the tee is pressed into a spring socket at the opposite side of the tank frame, the spring holding the tee firmly to the brass casting. A pin hole in the casting admits the air into the tee, its expansion serving to cool the air to near the temperature of the water in the can. The ice cans are held down firmly in the tank by a single cleat adjusted in an instant. The setting in of the tee pipes is also done quickly, one end of the horizontal part of the tee being pressed against the spring socket and the other allowed to spring into the reamed opening of the brass casting. The spring holds the air pipe firmly in place. There are no flexible connections and the air pipe stays where put until time for removal. Air pressure at about 6 lb. per sq.in. keeps the water in rapid agitation and prevents freezing of the orifice of the tee pipe. The latter is thrown out when all but from 10 to 15 per cent. of the water is frozen, the nozzle of a suction hose is dropped in and the water exhausted and replaced by distilled water. A practically coreless clear cake of ice results.

In another raw-water ice-making plant in Chicago, a somewhat different arrangement for supplying air to ice cans is used and no distilled water is required for the core. In this plant a tank containing 20 rows of ice cans is installed and a main air header is laid lengthwise through the center of the tank in the tank frame with a threaded nipple provided with an air cock opposite each transverse row of cans at each side, this main serving ten rows of cans the length of the tank. Similar air mains are laid at the extreme sides of the tank, these having nipples and air cocks to one side only and each serving five rows of cans.

Instead of a separate tee pipe for each can the tees are prepared in rows of five. They consist, in fact, of five pipes depending from a common cross pipe. One end of this cross pipe is sealed, the other end is threaded, the threaded end fitting into a union on the end of the threaded nipple of the air main. The cans are filled five at a time, the five-branched air pipe is set in, the cross pipe being supported on the cleats that hold the ice can rigid, and the connection at the union is made by hand without tools. At the same time the air cock or faucet is opened and the air flows into the five cans at once.

At this plant 400-lb. ice cakes are frozen and tee sets with depending fingers about 46 in. long are first inserted, but after the cake is about half frozen these are lifted out and tee sets with depending ends about 28 in. long inserted in their stead. When the water is frozen to within about 1½ to 2 in. the short-arm tees are removed, the center core of water sucked out and cold raw water from the forecooler tank is run in to fill the cavity. The covers are then replaced and the remaining water allowed to freeze. The result is a 400-lb. cake of clear ice with no more core than distilled water ice and with only a very small cup or depression at the top of the cake.

Jewell System

An entirely different proceeding is followed in the raw-water ice-making systems using stationary ice cans. In the Jewell system there is no freezing tank or brine tank such as is used in the ordinary can ice-making plant. Instead the ice can itself performs the function of the ordinary brine tank. The ice can first used had a double wall, with a ⅝-in. space between walls. The can has an extension at the bottom, termed a nonfreezing zone, which is not jacketed as is the rest of the can, and is only about one-third the width of the can. A recent modification of the system does away with the jacketed can, using instead an ordinary can with the nonfreezing zone extension at the bottom. These cans are permanently fixed in a tank, or "cell," with common connection through suitable headers, to brine cooler, air system, water supply, etc. As many "cells" are installed as the size of the plant may warrant.

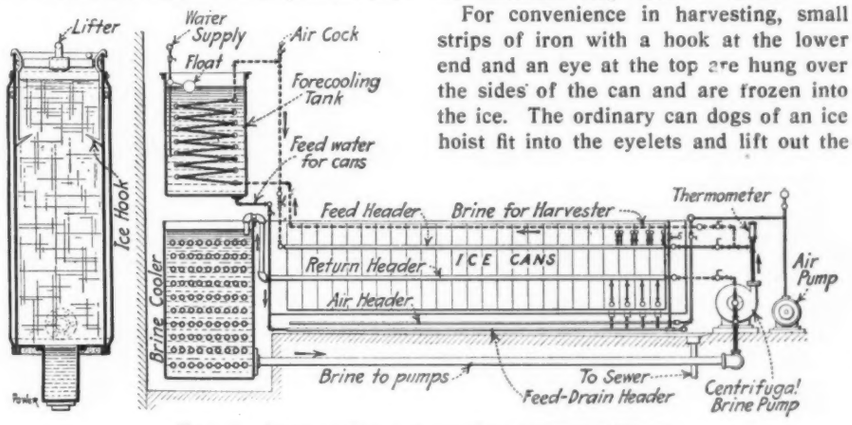


Fig. 1. Jewell Raw-water Ice-making System

The cans are arranged in rows, and the cells are insulated with 8 or 10 in. of granulated cork or other good insulating material. A ¼-in. air pipe from an air compressor or blower system is connected to the bottom of each can, the air pipe terminating in the upper part of the nonfreezing zone, and thus obviating any danger of freezing the orifice and blocking the air current.

After the cans are filled with water and the air current is turned on, cold brine from an adjacent brine cooler is circulated through the ⅝-in. space between the can walls or around the cans in the cell tank, by means of a small brine pump. The brine used is generally of low temperature, near zero in the jacketed-can type, but about 12 deg. F. in the cell type. The water in the jacketed cans is frozen rapidly, the ordinary sized 300-lb. cans taking from 26 to 34 hr. The rapid freezing makes it necessary to allow more time for tempering the ice before it is pulled, or cracking will result. When a row of cans is frozen, the brine flow is shut off and the brine remaining in the can jackets is put in circulation through the coils in the forecooling tank which contains the water for the next charge of the can. This partly warms the brine in cooling the water tank and at the same time gradually tempers the ice. This circuit is continued for from two to three hours or until the ice in the cans is loosened so the ice can be pulled. To facilitate the final thawing the water remaining in the nonfreezing zone is drained out and the next charge for the cans is turned on. The water, it should be added, flows to the cans by gravity, the quantity admitted being regulated by an automatic stop cock or valve.

For convenience in harvesting, small strips of iron with a hook at the lower end and an eye at the top are hung over the sides of the can and are frozen into the ice. The ordinary can dogs of an ice hoist fit into the eyelets and lift out the cake. A quick tap knocks the iron strips loose so they can be used over again.

During freezing all the impurities in the water are rejected and sink to the bottom into the nonfreezing zone. The writer has seen ink thrown into the water in the can yet a perfectly clear block of ice pulled. The liquid in the nonfreezing zone was fairly good writing ink.

Pownall System

In the Pownall system stationary ice cans are employed as in the Jewell system, but there the similitude ends. The cans are permanently fixed in the tank and are placed very close together, or with only about ⅞ in. space between the

cans. Well insulated covers are provided, as the cake is frozen from the top downward. There are no pipes or coils in the tank but brine from a brine cooler, usually placed alongside of the tank is circulated around the cans by means of propellers, the temperature of the brine being carried somewhat lower than is customary with distilled-water ice. At the bottom of each ice can are fixed flanges and connections to a water-inlet header and a water-outlet header and an air-supply pipe. All the cans in a tank, if of moderate size, or in a section, if the tank is large, are connected as a unit for water inlet and outlet, air supply and ice harvesting. That is, all the cans in one tank or one section of a tank are filled at the same time and pulled at one time.

Adjoining each ice tank, or section, is a precipitating tank having connection with the bottom of the cans through a common header. The precipitating tank extends somewhat lower; that is, is deeper than the freezing tank. The air current is admitted at the bottom of the can between the water inlet and outlet pipes through a ½x3½-in. nipple. The air pipe is so connected to the water pipes as to create a siphonic action, and cause the water in the can to rise to slightly higher level than in the precipitating tank, flowing then by gravity through the other water connection to the precipitating tank, thus maintaining circulation of the water. The purpose is to cause the impurities in the water, expelled during the crystallizing process, to collect in the precipitating tank where there is no air agitation and settle therein. Sometimes after freezing a tank full of water 4 or 5 lb. of solids are found deposited in the precipitating tank.

The air pipe mentioned is a small galvanized-iron pipe with ⅛-in. opening carrying about 2½ to 3 lb. air pressure. As a rule the air is not cooled or dried or expanded as in other systems, as there is no danger of freezing the orifice of the air pipe.

When the water in the cans is nearly all frozen, or say to within 3 per cent. in a 300-lb. can, the air pipe is shut off, the small amount of water remaining in the cans is drained off through a small pipe provided for the purpose and distilled water is let into the opening through another connection controlled by a valve. The freezing is continued until all the water is frozen into a clear coreless cake of ice. The brine circulation is then stopped and the ice is allowed to temper for an hour or so. Switched over to another connection the brine is then circulated through the coils in the water-storage tank holding the next charge for the cans, which cools this water and at the same time warms the brine enough to thaw loose the ice frozen in the cans. The ice is then lifted out of the cans by a hoist, small iron hooks having been frozen in, as in the Jewell process to furnish a hold for the cross-bar of the hoisting apparatus. It is claimed that from 10 to 12 tons of ice per ton of coal burned is possible with this system.

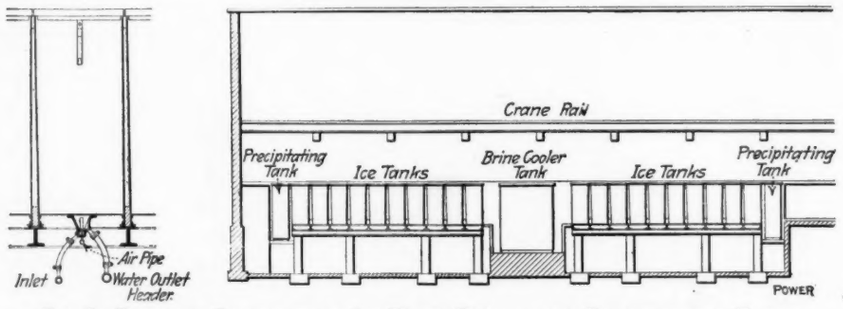


FIG. 2. POWNALL SYSTEM WITH ITS BRINE COOLER AND PRECIPITATING TANKS

CORRESPONDENCE

Making Calcium Chloride Brine

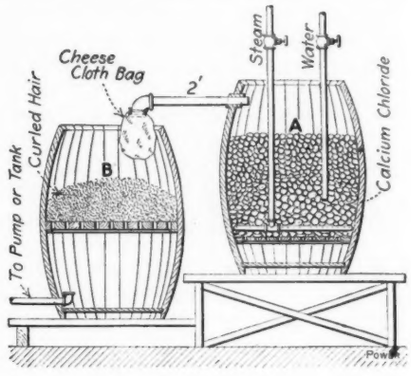
A simple apparatus for making calcium-chloride brine for refrigerating purposes, which I have used for some time with entire satisfaction, is shown in the accompany sketch, where *A* and *B* are two large tierces such as are used around packing houses for pickling purposes. The barrels hold about 300 gal. each and are on stands close together, one about 1 ft. higher than the other.

About 12 in. from the bottom of tierce *A*, I fitted a round cover the exact diameter of the tierce at that point and perforated it with 1-in. holes on 4-in. centers. This strainer is to allow all the nondissolvable matter in the calcium chloride to drop through to the bottom of the tierce, to be removed later.

A ¾-in. line supplies steam for boiling the solution. A 1x¾-in. tee on the end of the pipe is fitted with two semi-circular 1-in. pipes bent to fit the shape of the tierce and capped on the ends. The pipes are well perforated with $\frac{3}{16}$-in. holes close together which give the steam a free outlet into the solution with practically no noise even with the steam valve wide open.

A 1¼-in. water pipe extends down to within 1 ft. of the strainer, and about 4 in. from the top of the tierce is a 2-in. overflow pipe long enough to allow the brine to pass over into tierce *B*, where it is strained and delivered to the pump or direct into the freezing tank, as the case may be. Halfway down in tierce *B* is a strainer similar to the other one, covered with curled hair to catch any foreign matter or dirt that might pass over from tierce *A*.

At the bottom of the tierce is a 1¼-in nipple, with an elbow on the inside turning up, as an outlet for the brine. This



BRINE-MAKING OUTFIT

prevents any sediment that might filter through from going to the pump and thence into the system.

In making the brine I first cut up the drum of calcium chloride with an old rip saw into about six or eight slabs and break these up with a sledge into sizes about as large as an apple.

Tierce *A* is then filled about three-quarters full of the calcium chloride and water turned on until within 4 in. of the overflow. Turning on the steam I let the solution come to a boil and when it is strong enough, which is determined with a Baumé hydrometer, I open the water valve enough for the solution to slowly rise and flow over into tierce *B*, testing the solution often so that it will not get weak from adding too much water. The density of the brine can be regulated very closely with the water valve. As fast as the calcium chloride is dissolved more is added so that the tierce is always half full of calcium-chloride lumps. This method gives good results for the density we use, which is 30 deg. Baumé.

C. E. ANDERSON.

Chicago, Ill.

The smoke nuisance costs the United States $500,000,000 a year, is the estimate given by the department of industrial research at the University of Pittsburgh. This damage consists in the defacement of buildings, tarnishing of metals, damage to merchandise, injury to both human and vegetable life, increased cost of housekeeping and loss to manufacturers through the imperfect combustion of coal. The loss in Chicago alone is estimated at $50,000,000 a year.—*Gas Review.*

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POWER

Non-Return Stop Valves

A boiler tube in a large plant recently pulled out of the drum into which it was expanded, a number of men were seriously hurt and the service was interrupted. Had it not been for the heroism of an attendant who rushed through the steam-filled room, and closed the stop valve, thereby horribly burning his hands, every boiler would have lost its pressure, hours of idleness for the entire establishment would have followed, and possibly those in the boiler room would have been killed.

It requires an iron nerve and an extraordinary sense of duty to close a stop valve under such circumstances. Hardly ten men in a thousand would risk it. The nonreturn stop valve in such cases allows only the one boiler to be rendered unserviceable and the time saved thereby is an item usually in excess of the cost of the valves.

And this is not their only good feature. As with some forms of insurance policies it is not necessary to "die to win," with these valves it is not essential that a boiler be disabled to prove their advantages. We all know the care that must be exercised in cutting a boiler in on the line with others under pressure. The pressures must equalize before the valve is opened and if the steam gage on which the engineer solely depends for guidance is defective, disaster may follow the opening of the valve. The automatic nonreturn valve obviates this danger by not opening communication between the boilers until the pressures are equal.

Those who have advocated the compulsory use of nonreturn stop valves have met stubborn opposition. Plant owners are sometimes reluctant to believe that they will be benefited by installing such valves. It is learned that they protect the fireman in the event of a ruptured tube or seam. This is surely their paramount feature, but it is talked of so much that their other advantages are forgotten. This is unfortunate.

Railroads are liable to damages if a passenger slips on a car step not provided with an adhesive mat. This is because the mat conduces to safety and is a commodity on the market, the price of which is not prohibitive. Should not owners of boilers be liable for boiler accident, the dangers of which can be minimized by the use of the nonreturn stop valve?

The Engineers' Study Course

With this issue we commence a study course for engineers. The idea is not a new one. A similar course added to the popularity of POWER in the early nineties and many engineers who are occupying positions of trust and responsibility today owe their start to the opening thus afforded for self-instruction, and their initial impetus upon the road to advancement to the interest awakened by this course.

The engineer deals with quantities which must be computed, "figured," in their own magnitude and in their relation with other quantities. He ought to be an adept in arithmetic, he must have a clear conception of ratios and proportions and know all about percentage. The initial lessons of the course will lay this groundwork, but they will be made to teach something more than plain arithmetic by the selection of examples dealing directly with power-plant subjects, so that the student will be learning engineering as well as arithmetic.

Another purpose which will be persistently followed is that of teaching the reader to analyze a problem, to see the relations of various quantities to each other and know the unknown can be determined from the known rather than to load him up with a collection of rules to be learned by rote, or filed away to be hauled out, not always with the best discrimination, and applied with more or less precision to the case in hand.

As the problems in connection with these lessons will serve to a large extent the same purpose, the Study Questions which have been running for several months will be discontinued with this issue.

Snap Judgment

Some engineers are much too hasty in their condemnation of what might prove to be a highly useful article in their technical paper. They merely glance at its contents or cast it aside as worthless before they have given careful consideration to its purpose and endeavored to ascertain if it may not contain a solution of an operating problem that has been causing them hours of hard work and study.

The same critical judgment should be used by the engineer in reading his technical paper as is expended in investigating the claims made for a machine that is recommended for economical operation and efficiency. The careful and thorough engineer looks before he leaps, and he knows that while a machine may be worthless under certain conditions, under others it has often proved to fully answer its purpose.

He knows, for instance, that a mechanical stoker which will effect a good economy with a large-size coal is often a failure when smaller sizes are employed. A low-pressure steam turbine may increase the plant efficiency if added to an installation of reciprocating engines run noncondensing, but if operated with a low vacuum or run directly from a low-pressure steam system, its use may be highly inefficient.

Snap judgment is studiously avoided by those engineers who are always seeking for the best, whether it is a machine or an article in their technical paper. Both of the latter have their right uses, and, in determining what such may be, one is deserving of careful consideration as well as the other.

The Junkers Engine

For the past two or three years the Diesel engine has been a central figure in engineering discussions due largely to its exceptionally high efficiency and to its extended use abroad.

In spite of its many advantages, however, it possesses certain inherent features which tend to make the first cost high, the construction somewhat complicated, and the employment of skilled labor necessary.

The Junkers engine, which is now attaining some popularity in Germany, operates on the Diesel principle, but is entirely different in construction from the latter engine. Its internal parts are much simpler as no valves nor cylinder heads are employed and the castings are very plain. Moreover, its reciprocating parts are perfectly balanced. On the other hand, its external parts are somewhat complicated.

In the series which is now running in our "Gas Power Department," the author sets forth the contentions of Professor Junkers in support of his engine, which include interesting comparisons with the Diesel engine. Our pages are always open to useful discussion, and we trust that our friends, especially those who are Diesel adherents, will take this opportunity of expressing their views. Professor Junkers will be given an opportunity to reply to all comments and as far as possible we shall endeavor to print the comment and the reply in the same issue.

Self Overvaluation

It is but natural that the engineer, who by dint of years of study and hard labor has become head of a power plant, should be inclined to overvalue his services to his employer, especially when his plant operates a factory.

Admitting that industrial success is in a way dependent upon the economical operation of the power plant, it is a fact not to be lost sight of that the average factory manager regards the power plant as an incidental. In some industries the entire cost of manufacture has been placed as low as two or three per cent.

If such is the case, the engineer becomes but a slim spoke in the industrial wheel. He may claim that "nothing can run without him," but he must also know that without the factory and its product his services are valueless.

The factory manager welcomes his returning salesman with a warm grasp of the hand, because through him is found a field for the factory output. But this same manager will frown on the approach of his chief engineer and brusquely inquire: "Well, what is it now, more repairs, supplies, or is it another breakdown? Every time I see you coming it means some additional expense."

The estimation in which an engineer is held by his superiors largely depends upon the former's personality, and while he should cultivate a certain amount of self-assertion, he must also bear in mind that but few superiors will accept him at his own valuation. Managers have apparently taken it for granted that the power plant is a necessary evil, and if the engineer hopes to escape humiliations and rebuffs, his best plan is to try to reduce the "evil" to its lowest possible denomination.

Dealing with Meddlers

Blocking the meddler is one of the disagreeable, but often very vital duties of the power-plant engineer. The very breadth of engineering activity offers a tempting field for the man who delights in finding fault and thinks he can show the engineer up in a poor light.

Between legitimate inquiry and meddling the line is very flexible. It changes according to persons and circumstances and is fixed sometimes by tact. The owner may be a meddler instead of a judicial supervisor. The meddler may be a poorly selected representative of the owner, incapable of carrying out his intended functions, or one of the office boys looking for a chance to gain favor of the owner.

Competent, authorized persons are at all times entitled to the fullest knowledge of power-plant conditions. Correctly made-out reports from the engine room, with the ability to elaborate upon them if required to, meet this situation. When the inquiring is inquisitiveness or just plain meddlesomeness, it is still best to be able to explain, and if necessary over the head of the meddler. Every failure here is a reflection upon the profession; every victory a credit to all engineers.

The man with education, not necessarily collegiate, tempered with tact, seasoned with observation and study, tied with hard knocks, with experience behind him to back up his statements is the man who can block the meddler.

Here is an apparent excuse for using a big word. The literary fellows tell us that using big words only because they are big, is a vice, but a big word, when it is the best word, needs no apology. Besides, if we were sticklers for "the simple folk vocabulary of our Saxon forebears," we could not always find words to express our meaning, particularly in engineering experience.

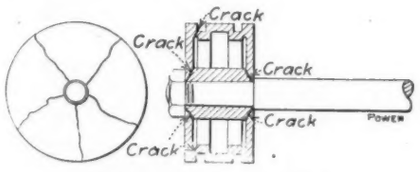
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Mysterious Piston Fracture

Recently I had charge of a 12x12-in. duplex single-stage air compressor working against 100 lb. receiver pressure, to which three accidents of exactly the same nature happened that I have not been able to account for, to my satisfaction, and would like to hear from readers as to their theory of the cause.

The illustration shows the nature of the accidents very clearly. A vertical section and an end view of the head are shown, indicating the nature of the fracture. Nothing was left on the rod except the hub or eye through which the rod passed. It would appear that the fracture was caused by a force acting from within the piston. My conclusion from the first accident was that water had accumulated in the head in some manner and during high compression had generated into steam and exploded the head, but when the head on the other side broke in exactly the same way a short time after, I lost confidence in this conclusion, and when in less than a week the piston which we had renewed fractured likewise, it weakened still more, for it would hardly seem probable that all three could be faulty in this manner. After the third accident I had solid heads put in and had no further trouble. What was the real cause?



BADLY CRACKED PISTON

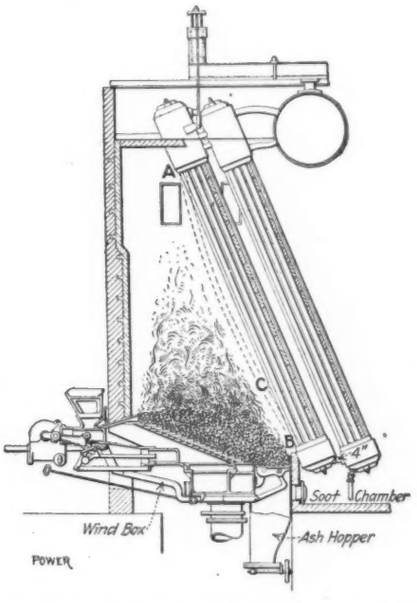
H. R. ROCKWELL.

Alten, Ill.

Interesting Boiler Experience

When our four 500-hp. water-tube boilers, equipped with mechanical stokers and using balanced draft, supplying steam for an induction-motor load varying from zero to 4000 kw. were started about two years ago, everything went well for a few months; then one night a tube broke at *A*. Very little was thought of this, and it was "logged" that the tube had been cut when expandedfi thereby causing the leak. In a couple of days a tube broke in another boiler. This continued until it got so that when one boiler was cut in, another boiler was ready to be cut out, but we were fortunate in not having two boilers cut out at once. It was the front tubes of the front units that always gave out. Each unit has twenty-one 3¼-in. tubes 18 ft. long. Two units and part of the steam drum are shown herewith. The tubes would crack at either *A* or *B* and frequently a blister would be raised as at *C*.

Numerous causes and their proper remedies were suggested by those about the plant. Some said the only remedy was to install two more boilers. Others said charcoal-iron tubes would prevent further trouble; while another claimed that the ends of the steel tubes should be annealed. Another contended it was the fireman's fault for carrying the fires too heavy and getting the tubes too hot, while another stated that the fires were carried too light, allowing holes to be blown in them, creating a blow-pipe effect on the tubes, thus forcing the water away, causing steam "bubbles" and overheating of the tubes. Another blamed the damper regulator for not being sensitive enough. It used to vary about 7 lb. from closing to opening. By the time the fan came up to speed a sudden load came on, and the pressure would drop 10 to 15 lb. This, he claimed, caused the boilers to prime. With the sudden drop of pressure the temperature of the steam would also drop, but the water would retain its temperature and tend to flash into steam at the reduced pressure. While this action was going on the front of the front tubes being in contact with the hottest gases, would overheat, causing them to sag as shown by the dotted lines.



PARTIAL SECTION OF WATER TUBE BOILER SHOWING DEFORMATION OF TUBE

Another said the 4-in. nipples which connected the units at the bottom, did not allow sufficient water to pass through, especially when they were coated with scale. He held that the great fluctuation of the water level every time a load was thrown on suddenly proved his claim. This was brought to the attention of the boiler manufacturer whose representative said that when the draft fan was stopped the induced fan would circulate cold air around the tubes, especially if one of the cleaning doors was opened, and this caused the tubes to warp.

Discussion continued and the tubes kept breaking until the company shut down an old street railroad station and transferred its load after installing three 500-kw. rotary converters. There was an immediate improvement; the synchronous motors raised the power factor, a big decrease in coal consumption per kilowatt-hour resulted, and the peak load could go to 5500 kw., without a decrease in steam pressure. The load seldom drops less than 700 kw. This keeps the fires hot all the time, and at present the peak load does not go over 4500 kw. Three boilers are used, the fourth being banked the greater part of the time.

THOMAS SHEEHAN.

North Adams, Mass.

Passing of Some Notable Engines

Only a few years have passed since the late P. W. Willans, of Willans & Robinson, Ltd., Rugby, England, came forward with his high-speed engine. It was to revolutionize the engineering business and provide an ideal motive force. Licenses for its manufacture were granted to American, German, Swiss and French engineers. Now, not only is the engine no longer made, but that it ever existed is almost forgotten, even at Rugby.

In conjunction with Mr. Willans, two others should be named as pioneer builders of high-speed engines, W. H. Allen, of W. H. Allen & Son Co., Ltd., now of Bedford, England, and who is still actively engaged as the head of a huge business, and the late Peter Brotherhood, of Brotherhood, Ltd., now of Peterboro, England. At this period these firms were all established in London and no doubt

the success of this engine was the prime cause of all of them establishing modern works in the provinces. It was quite common to see a long line of these engines in British power stations some fifteen to twenty years ago.

There are still several firms engaged in making high-speed engines in Great Britain. The Allen generating sets (which are made complete at the Bedford works, and for which Mr. Allen may also be termed a pioneer of electrical engineers, the firm going into the electrical business almost before it was a commercial success) are extensively used, especially in the British Navy, and upon ships generally. They were installed on the "Olympic" and her ill-fated sister-ship. But this firm for some time has been engaged upon the turbine and oil engine, as are most of the other British firms connected with this branch of industry. As it is doubtful if any firm outside of Great Britain is making this type of engine now, its end may shortly come to pass, and its place be taken by something more reliable and economical.

Another event was closely connected with the introduction of this engine. Prior to this time, shops were run on more or less secret lines—under old conservative ideas. There was little interchanging of thought between shops, much less between nations. After inventing his engine, Mr. Willans read a paper before the Institution of Engineers in London on "The Willans Engine and Its Construction" which marked the opening of a new order of things. Criticism was plentiful, but Mr. Willans convinced most that his ideas were correct, and the secret method was dead. Today we rejoice in the "open shop." Papers are read and transmitted broadcast by the press, representatives of various nations, especially British, American and German visit each other and are received with open arms wherever they go. In this America may be said to lead.

We give publicity to our ideas and court the criticism of the world, but for the late Mr. Willans to do so some twenty years ago, was then thought worse than folly.

F. P. STRACHAN.

Belfast, Ireland.

Flywheel Fan

Engineers having engine rooms with low ceilings and poor ventilation can improve conditions during the hot months by adding a fan to the flywheel or other wheels that may be handy. I use two sheets of medium-weight galvanized sheet iron about 10x30 in. clamped to the flywheel arms with U-shaped clamps having one end about 1¼ in. longer than the other, so as to give the blade the proper pitch. The speed of the engine is 170 r.p.m. Care should be taken to draw the air from the direction in which it will not take up dust.

A fan as arranged will cool the room and also the main bearings and eccentrics. Before attaching the blades it must be determined how large they should be and whether or not the engine will properly carry its load with blades so attached.

C. V. COOPER.

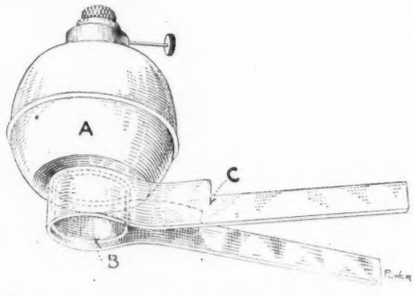
Greenfield, Mo.

Useful Hand Lamp and Holder

The usual type of oil lamp is inconvenient and clumsy in many places. Especially is this the case when expanding tubes or working inside a firebox or smoke box of a locomotive or other type of boiler. Shops where portable electric lights are available do not need such lamps, but they are very good in other plants.

A foreman boiler maker of a portable-engine works making locomotive-type boilers is the inventor of the lamp and holder shown. The device is simple; a small lamp with a globular tin container *A* fitted with a stem to turn up the wick is the type chosen and purchased as required. The lamps have a short piece of 1-in. diameter thin brass tube *B* soldered to the center at the bottom.

The holder is made of $\frac{1}{16}$-in. spring steel 1 in. wide. The part which encircles the tube is $\frac{7}{8}$ in. diameter, so that when the holder is sprung on the tube at the bottom of the lamp it grips it and leaves the two free ends of the holder about 3 in. apart.



HANDY LAMP FOR USE WHILE CLEANING BOILERS

The free ends of the holder when pushed into a tube exert a pressure on the tube walls, which holds the lamp from turning. It will be noticed that the free ends are reduced in width. The shoulder thus formed prevents the ends being pushed too far into the tube.

When stood on a flat surface the splayed ends of the holder prevent the lamp from being readily overturned. It may be seen that any lamp of suitable shape can be converted into this type with little trouble.

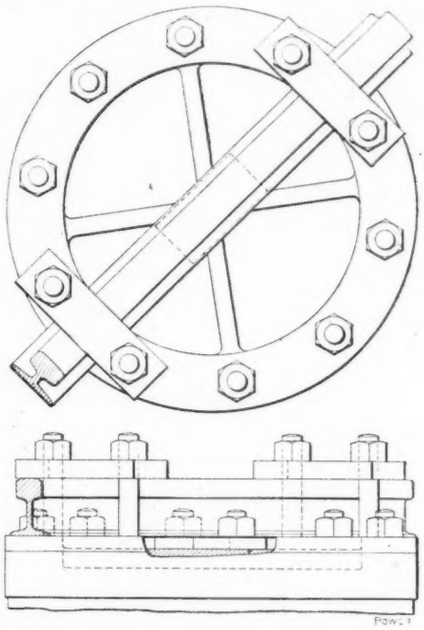
A. L. HAAS.

London, England.

Poor Gaskets Served Good Purpose

Recently we installed an 18½x17-in. engine belted to two generators. This outfit was second-hand and has caused all manner of trouble.

One morning this engine was started in the usual way, allowing about 10 min. to get up speed by admitting steam very slowly. Everything seemed all right, but as the engineer was about to cut in the generators the cylinder cracked in four



STEEL RAIL HOLDING FRACTURED CYLINDER HEAD

places. I immediately shut off the steam and started to investigate. Water was all over the floor and some was still dripping from the cylinder-head joint. The cracks were about 1½ to 2 in. long, all centering at the ⅜-in. eye-bolt hole. The breaks showed plainly on the outside, but could not be seen on the inside of the head. Upon removing the head we found that the gasket was nearly all gone, the pieces being found later on the floor.

This damage was done by entrapped water, notwithstanding that the cylinder has two 1½ in. relief valves and both were wide open. There is also a ½-in. bleeder on the steam chest, which was open. I have a very warm spot in my heart for that gasket, because I believe that if it had not blown out, the cylinder head would have done serious damage.

Fortunately the head was not damaged beyond repair, so we removed four of the studs from the cylinder and put in their place four 9½-in. studs, and then bolted a piece of track steel across the face of the head, as shown. This head is recessed so we had to put an iron block in between it and the rail. After this

repair the engine was started and has been running every day since with no indication of giving away.

This only serves to warn the engineer that he cannot be too careful about thoroughly draining the steam pipe before starting the engine.

J. B. DANIEL.

Chicago, Ill.

Favors Non-Return Stop Valves

In nearly every power-plant paper that one may pick up is cited an account of some accident to boilers or steam piping under pressure in which life is lost or endangered from the escaping steam and water. Many of these accidents could be avoided by using non-return valves on the boiler branches which would close at the time when it is most important that they be closed.

I have been through three of these accidents, and a fourth happened about 15 min. after I was relieved by the night man. The first two were almost identical and were each caused by a split tube in a water-tube boiler. There were six 250-hp. boilers on the line under 150 lb. pressure and nothing but common high-pressure gate valves on the branch between the boilers and header. The only damage was to the foreman who was burned. The mill was shut down for 1½ hr., but the cost of the accident in each instance, in time lost in the mill getting started again, was enough to equip all the boilers with non-return stop valves. The third was caused by a 10-in. steam pipe pulling out of a flange; no one was hurt, but it was impossible to close the valve as it was near the break, and each boiler had to be cut out by hand and the fires drawn.

The cost in this case would have nearly paid for the installation of these valves. The fourth was caused by water-hammer breaking the stop valve while the boiler was being cut in on the line, and nearly cost one man his life, and shut the whole plant down for about two hours. If there had been automatic valves on the boilers in these instances the trouble would have been local, and would not have affected the whole plant as it did.

Some of the nonreturn valves only close in one direction, that is, against the header pressure. This will cut out the boiler if a tube bursts, but would not close against the boiler pressure if the steam pipe burst. I believe they should close either way. Boilers are not any too safe at their best after they have been in use a few years, and I consider the non-return stop valve just as necessary from a point of safety as any other appliance except the safety valve. The inspection laws should be so amended that their use will be compulsory where two or more boilers are connected to a common steam line.

A use for the non-return stop valve on the boiler, other than its operation in case of accident, is in cutting the boiler in or out of service. The usual procedure where hand-operated stop valves are used is to watch the steam gage until the pressure appears to be about equal to that of the boilers in service, then hurry to the top of the boiler and open the valve. Sometimes, due to the gage being inaccurate or other reasons, there may be 5 to 15 lb. difference in the pressures, or the fireman's attention may be called to something else at that time and the pressure in the boiler may become too high, which makes cutting in more dangerous. This would be avoided by using these valves.

These conditions help to increase the number of Monday-morning accidents. With the non-return stop valve in use the hand-operated stem may be screwed up (if it has been closed) at any time while raising steam, and when the pressure in the boiler is equal to that in the steam line the valve will open of its own accord whether the fireman is watching it or not.

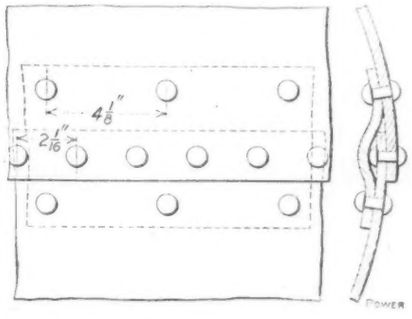
J. C. HAWKINS.

Hyattsville, Md.

Boiler Joint Problem

I submit this longitudinal boiler joint to the readers with the idea that some of them will figure its efficiency and so engineers in other parts of the world will realize what the applicant for a second-class engineer's license is "up against" in Massachusetts.

This joint is supposed to be a locomotive joint, but we in Massachusetts call it a "preventive joint" as it was put in a single-riveted lap-jointed boiler to prevent the boiler going to the scrap heap.



REINFORCED BOILER LAP JOINT

The style of joint is single-riveted lap-seam with one cover strap. The dimensions are:

Plate thickness, 5/16 in.; tensile strength, 55,000 lb. per sq.in.; inside pitch, 2 1/16 in.; outside pitch, 4⅛ in.; rivets, ¾ in. diameter after driving; shearing strength, 42,000 lb. in single shear, 78,000 lb. in double. I took this up with our boiler inspector and we found the weakest part of this joint to be the three rivets in single shear, their strength being only 0.785 that of the solid plate.

The cover strap is pounded in a little snugger to the rivet in the shell lap than my sketch shows.

JOHN H. ARMSTRONG.

Adams, Mass.

Effect of No Lubrication on High Speed Engine

An engineer at a coal-mine power plant neglected to open the feed valve on the lubricator of a 16x18-in. automatic engine running 225 r.p.m. and belted to a direct-current generator which furnished power to the mining machines. As his duties included the blacksmith work and repairs around the mine, no further attention was paid to the engine until it suddenly stopped shortly after noon, with the rocker-arm broken and the screws loose in the rocker-arm brackets. The broken rocker was replaced by one removed from an engine at another mine near-by, and the engine started. After running a few minutes it was necessary to stop as the bracket could not be kept in place.

The cylinder head and steam-chest covers were then removed and the valve and seat were found so badly cut and worn that a new cylinder, piston and valve were needed before the engine was again ready for service. These parts were removed from the engine at the other plant and after being placed in position the engine ran without trouble. The damaged engine had been in service only two years and was purchased new.

C. C. SIDINGER.

Salem, Ohio.

Zinc Paint as Corrosion Preventive

The drums of our water-tube boilers showed signs of rapid corrosion, due undoubtedly to the presence of sulphuric acid in the feed water. To stop this action we painted the interior of the drums with graphite. The results were not wholly satisfactory, so we painted the parts affected with zinc paint.

Although we have not been using this paint long, the results so far are very pleasing.

J. E. ASHBAUGH.

Clarksburg, Penn.

[If the feed water is highly corrosive, coating the drum with paint containing zinc may give good results while the paint lasts, which will not be long. Zinc slabs hung in the boiler would give better results with less work on the part of the boiler attendant.—EDITOR.]

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Equalizing Cutoff Throughout Governor Range

Mr. Low's article on the Corliss engine in the issue of Sept. 10 was indeed interesting and instructive.

On page 379, he suggests that some means of equalizing the cutoff on the two ends of the cylinder throughout the range of the governor should be devised.

About ten years ago I was trouble man for a firm building four-valve and Corliss engines and had a call to a 30x42-in. noncondensing Corliss engine, which was giving trouble with the dashpots, among other things. If the cutoff was equalized for about quarter stroke, at no load the head end got practically no steam, and the dashpot would not handle the valve under those conditions without special adjustment which was unsatisfactory at normal load.

The knock-off cams were arranged similar to Fig. 1. To try the action of the valve-gear with the cutoff equalized, or nearly so, from lead to about one-third stroke, I moved the knock-off steel on the crank end so that the cams stood similar to Fig. 2, when cutting off at the same point as represented by Fig. 1, which was for no load. As will be noticed, the lever arm *A*, Fig. 2, is considerably shorter than when the cam stood as in Fig. 1, and on this account, when the governor reach-rod moves in the direction of the arrow for a longer cutoff, the crank-end cam will move through a greater angle than the head end and thus tend to correct for the angularity of the connecting-rod.

The builders adopted the idea at once and determined in the drafting room the proper ratio between the cam arms, and sent a new cam with a longer arm for the head end, as that was more easily changed, and the crank-end cam was put back to the original position. This arrangement was adopted for all engines and it worked closely throughout the range of the governor.

The disadvantage of this method is that the head-end valve will have a smaller opening than the crank-end valve for a given point of cutoff, especially if it is late, and the higher velocity of the piston combined with the smaller opening will tend to show more wire-drawing on the head-end indicator diagram than on the crank end. To overcome this I proposed to make both knock-off cam-arms the same length and either make the head-end hook lever shorter or the wrist-plate radius longer to give practically the same valve opening and cutoff on the two ends throughout the range of the governor.

The builders preferred to keep the heavy parts of the valve-gear symmetrical rather than take advantage of the better admission line on the head end and so adopted the unequal length knock-off cam levers as the simplest means of equalizing the cutoff. Changing the cams did not cure the dashpot trouble entirely, but helped appreciably.

E. P. HAINES.

Philadelphia, Penn.

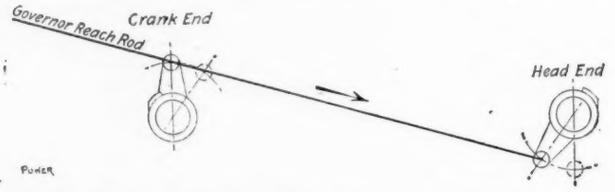


FIG. 1. REACH ROD AND VALVE ARMS AS ORIGINALLY SET

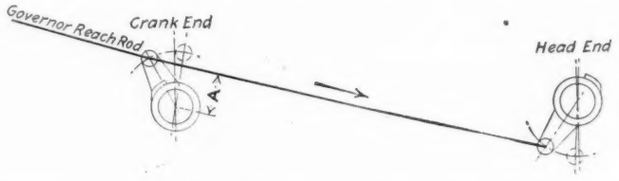


FIG. 2. SETTING TO EQUALIZE CUTOFF THROUGHOUT GOVERNOR RANGE

Zinc Slabs as Corrosion Preventives

Mr. Stafford, who inquires, in the Oct. 1 issue, as to hanging zinc slabs in boilers to prevent corrosion, should locate them so as to have a good electrical contact between the zinc and iron, and have the zinc where scale or deposit will not cover it. The idea is to make an electric couple out of the zinc and iron, and hence corrode the zinc rather than the boiler. It follows that as the zinc is effective only insofar as it is itself eaten away, that it will not last forever, but must be renewed, that many thin plates located at various points are better than one large chunk of twice their weight, and that any actual free acidity of the feed water should be neutralized with soda. Some sugar-plantation engineers using bad feed water report the zinc plates as very effective. Some of these plates should be anchored near the feed-water inlet.

DONALD M. LIDDELL.

Elizabeth, N. J.

Care of Baffles in Boilers

Mr. Wing's remarks as to the importance of caring for the baffling in water-tube boilers, in the Sept. 3 issue, I wish to corroborate. The least one can do is to replace the absent bricks and even then the baffling often is not put in good condition. owing to the springing apart of the tubes.

While the holes caused by such breaks are not large, they are many. If the surface of the brick is fused, it helps to close the holes, in which case it would seem unwise to use a spreader, as spreading will reopen them. Trimming the corners of new brick with a half-round file, striking a glancing blow does not weaken the brick and conduce to disintegration later on as is the case when unskillfully trimmed. Little trimming is needed to make a brick turn into place.

From long service baffles become unable to resist a crushing stress but are still tight as baffles. To spread the tubes to replace one brick might therefore crush several adjoining ones. There is a time when it is best to renew a whole set of baffles, but experience leads me to defer that as long as it is possible to patch the old, as rebaffling leaves so many holes. My experience has been mostly with double-deck boilers, when most of the holes have to be patched by applying the refractory material with the end of a stick 3 ft. long, although with the proper tools a new brick can easily be put in.

Another evil of rebaffling is that the tube bricks that are partly set into the side walls are sometimes broken out or disturbed, making patching at long range very difficult, especially as the flame

plates do not always extend near enough to the side wall to afford backing for the plastic material that must be used in patching.

Another place to watch in double-deck boilers is the space between the tube nests. The bricks used here being thin and light for their flat area, fall down, due probably to using steam-blowing apparatus for cleaning the tubes, the flame plates not being close enough to prevent the steam knocking them down.

I remedy this by laying a platform of baffle brick on top of the tubes and laying on this ordinary firebrick and refilling the space. This is done by a thin-chested fellow, who can crawl in, or by using boards on which to slide the brick in and sticks to guide them into place. This requires a hole to be made through the side wall.

All these things and the fact that some of the openings can be stopped only with difficulty out of all proportion to their size, has convinced me that no baffles are as tight as they should be. I find I am not alone in this belief as I have heard of forms being fitted to the tubes leaving a space into which the refractory material is run around the tubes, but with what success I do not know. It shows, however, that someone wanted a better baffle.

If it was my job to keep the baffling in order, I should not be so afraid of the chief crawling into the setting. as of his looking into the cleaning holes when the flames flowing through show where the holes exist, even revealing defects in the back baffles if the draft is strong. Looking into the holes is interesting to me aside from what can be learned. Through the top hole of the middle pass when the damper is closed and not too soon after coaling, the slow burning of the gases gives a peculiar vivid glow. When the damper opens and the gases take on motion and roll up, over and down, filling the whole space and beating against the bridge-wall, a very avalanche of flame, it is a grand sight to see and teaches the engineer that it is inexcusable to neglect the baffles and walls when the best that can be done is to keep the soot out and the setting in the best possible condition.

A. N. BOGART.

New York City.

Emergency Repair to Air Compressor

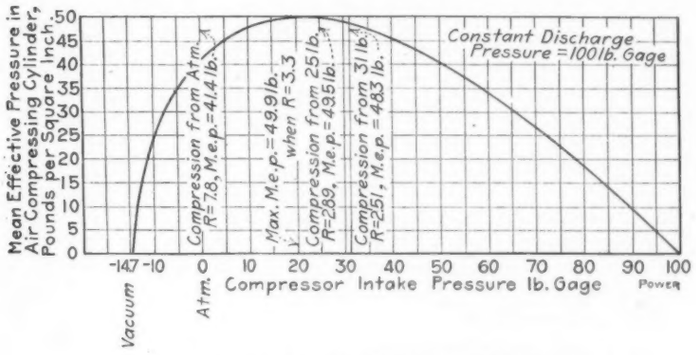
W. M. Fleming's letter on this subject, on page 431, Sept. 17 issue, brings out some curious facts about the compound or stage compression of air.

No doubt those who coupled up the 10x10-in. single-stage machine to act as the high-pressure side for the 20x8-in. low-pressure cylinder were not aware that when they caused the 10x10-in. machine to pump air from 25 lb. to 100 lb. they were subjecting it to a 20 per cent. overload, if designed for pumping from atmosphere to 100 lb. as it probably was.

The reason for the curious fact of increased horsepower when pumping through the smaller range of pressure is inadvertently given in Mr. Fleming's last paragraph where he says that the indicator cards of the 10x10-in. machine showed much more air compressed when pumping from 25 lb. pressure than when pumping from atmosphere. As a matter of fact it was handling more air; just about

$$\frac{25 + 14.7}{14.7} = \frac{39.7}{14.7} = 2.7$$

times as much. I say "about," because the decrease in compression ratio would materially increase the volumetric efficiency of the 10x10-in. machine and it would really be handling somewhat more than 2.7 times its usual atmospheric intake capacity.



INTAKE-DISCHARGE PRESSURE CURVE

This increased quantity of air pumped naturally takes more horsepower to compress it, hence the overload of 20 per cent. in power required. This horsepower increase is nowhere near the air capacity increase, and there was a considerable net gain. The fact that the 10x10-in. machine was able to stand the overload for continuous running speaks well for the design. I am wondering if some of the bearings did not heat.

Mr. Fleming says they adjusted the unloader on the 20x8-in. cylinder, to bring the intercooler pressure to 25 lb. This probably was done because the original intercooler pressure of the 20 and 12 by 8-in. machine was about this point and any increase would overload the 20x8-in. cylinder and its bearings. If, however, the 10x10-in. machine successfully withstood the 20 per cent. overload, the 20x8-in. might stand some, too, and by not closing the regulator, or unloader, to such an extent they might pump still more air.

In pumping from atmosphere to 25 lb. gage, the mean effective pressure is close to 16.98 lb. per sq.in. If now they had opened the regulator or unloader a little, allowing the intercooler pressure to rise to 31 lb. gage, the mean effective pressure in the 20x8-in. cylinder would have been about 19.82 lb. This is a 16.7 per cent. overload above 25 lb. operation. The mean effective pressure in the 10x10-in. cylinder pumping from atmosphere to 100 lb. gage, is close to 41.4 lb., and when pumping from 31 lb. to 100 lb., the mean effective pressure in this cylinder would be about 48.3 lb., which is about 16.7 per cent. overload above 41.4, the usual mean effective pressure for which the machine probably was designed. Thus with 31 lb. gage in the intercooler we have 16.7 per cent. overload in the 20x8-in. cylinder and 16 per cent. overload in the 10x10-in. cylinder, the same in the two cases, and we know already that the 10x10-in. machine is good for at least 20 per cent. overload.

The advantage of this is that by decreasing the overload in the high-pressure 10x10-in. compressor from 20 to 16.7 per cent. and putting 16.7 per cent. overload on the 20x8-in. cylinder, there would have been pumped about

$$\frac{31 + 14.7}{25 + 14.7} = \frac{45.7}{39.7} = 15 \textit{ per cent.}$$

more air.

Thus, if they had needed the air, balancing the overload to about 17 per cent. on each machine would have obtained about 15 per cent. more air than when simply overloading one machine 20 per cent., as they did. No doubt they had enough air, as I believe Mr. Fleming says, but these facts, if understood, might have helped them if more air was needed.

Many may not see why increasing the intake pressure of the 10x10-in. compressor from atmosphere to 25 lb. gage causes a 20 per cent. overload on this machine, and a further increase of the intake pressure from 25 to 31 lb. will reduce the overload to 16.7 per cent. The fact is that with a given discharge pressure, an increase in the intake pressure will produce an increase in the mean effective pressure and horsepower, until the compression ratio reaches 3.3; that is, when the absolute discharge pressure is 3.3 times the absolute intake

pressure. For 100 lb. gage discharge, this point occurs when the intake pressure is

$$\frac{114.7}{3.3} = 34.75 \text{ lb. abs.}$$

or about 20.06 lb. gage. Above this intake pressure the mean effective pressure decreases again, as may be realized by observing that with 100 lb. intake and 100 lb. discharge no compression occurs and no work is done; there is no mean effective pressure. This may be seen in the accompanying diagram of mean effective pressure with 100 lb. gage discharge and various intake pressures from vacuum to 100 lb. Zero mean effective pressure occurs at two points, when intake is at absolute vacuum, because the cylinders would then have no air to pump, and when the intake pressure is equal to the discharge, as before stated. This occurs with a dry-vacuum pump also, and with 30-in. vacuum, at sea level, the pump would develop no horsepower. It would also develop no horsepower if the vacuum were completely broken. The maximum indicated horsepower occurs at ratio 3.3 as before, which would be at about 20.8 in. of mercury.

With the air compressors under discussion, when the intake of the 10x10-in. machine was made, 25 lb., the mean effective pressure, although 20 per cent. greater than when pumping from atmosphere, was less than the possible maximum occurring at 20.06 lb., and a further increase to 31 lb. intake pressure would actually decrease the mean effective pressure and overload on this compressor, although it would equally overload the 20x8-in. machine.

This problem of variable intake pressure considerably complicates the work of pumping natural gas, which often occurs at high well pressure and is subject to considerable variation, with ultimate decrease as pumping continues, sometimes resulting in increased horsepower with reduced capacity and sometimes a decrease of both. It depends upon the compression ratios.

Upon again reading over Mr. Fleming's article I find a peculiar situation. He says the 10x10-in. compressor was a duplex (two-cylinder) machine. Assuming that both the 8-in. and 10-in. machines ran at the same speed (no speeds being specified), the cylinder ratio produced by pumping from one 20x8-in. cylinder into two 10x10-in. cylinders would be as their piston displacements, or about:

$$\frac{20^2 \times 8}{2 \times 10^2 \times 10} = 1.6$$

Assuming also that the broken intercooler tube was plugged and the cooler working, the intercooler pressure produced should have been about

$$1.6 \times 14.7 = 23.5 \text{ lb. abs.}$$

or 8.8 lb., say 10 lb. gage if the cooling effect were poor.

If the 20x8-in. machine ran at a greater speed than the 10x10-in., say in the inverse ratio of their strokes, the equivalent cylinder ratio produced would have been about

$$\frac{20^2}{2 \times 10^2} = 2$$

This would produce an intercooler pressure of about

$$2 \times 14.7 = 29.4 \text{ lb. abs.}$$

or 14.7 gage, say 16.5 gage for poor cooling.

These figures are based upon using the entire output of the 20x8-in. cylinder, and if, as Mr. Fleming says, they throttled the intake to this cylinder, its capacity would have been decreased and the intercooler pressure further lowered. How they obtained 25 lb. gage in the intercooler is a mystery to me. He does say they adjusted the unloader of the 10x10-in. machine, but choking the intake to this machine would have resulted only in piling up the pressure in the 20x8-in. cylinder, only to be reduced again to the pressures already figured—either 10 or 16.5 lb.—at the intake to the 10x10-in. cylinders. No amount of throttling between stages can affect the intake pressure to the second stage short of absolute closure, and the pressure will accommodate itself to do this independently of throttling between stages. This pressure depends only upon the ratios of cylinder volumes and the temperatures. The high-pressure cylinder must handle all the low-pressure cylinder gives it. If they throttled the second-stage intake, why did they throttle the 20x8-in. intake? These two operations would have opposite effects.

In view of these facts and that Mr. Fleming definitely states that they throttled the 20x8-in. intake, I think he must mean they entirely closed the suction of one of the 10x10-in. cylinders (or otherwise stopped its action) when they "adjusted the pressure regulator" on that machine. That would give a ratio of

$$\frac{20^2}{10^2} = 4$$

(assuming equal piston speeds), and this would produce an intercooler pressure of

$$4 \times 14.7 = 58.8 \text{ lb. abs.}$$

or 44.1 gage, say about 46 lb. for poor cooling. Then by throttling the intake to the 20x8-in. cylinder, as he says, they could have brought this pressure down to 25 or 31 lb., and obtained the results in horsepower and capacity described. Even then it would have been better, if they needed the air, to use both 10x10-in. cylinders and the entire unthrottled capacity of the 20x8-in. cylinder, letting the cooler pressure come where it would, 10 lb., or 16 lb., or 20 lb., depending upon the actual relative speeds of the two machines. This also would have added only about the same overload as before to the 10x10-in. machine (see the curve) and would have greatly reduced the power of the 20x8-in. cylinder by the reduction of its discharge pressure. Balancing the work in the two stages results in minimum horsepower, but when the balance is obtained by throttling the intake there is still another loss, as a partially closed intake controller, while it does reduce the air capacity, it scarcely reduces the horsepower at all until almost entirely closed.

I think the 10x10-in. machine had but one cylinder and was not a duplex. At any rate the problem is of unusual interest to figure upon in the light of the facts set forth in the accompanying curve.

R. S. BAYARD.

New York City.

The Man Who Wins

Through its forewords and editorials POWER always seems to be trying to help the engineer better his conditions by close attention to business, and study of the books that teach the ways of overcoming the difficult problems that are encountered in this work. A few engineers as well as other employees still have the distorted idea that they should do no more than they think they are being paid for, and who wonder why their salaries are not increased as fast as that of their neighbor, who is always trying to do what he can to cut down the cost of operation a little, or to make himself worth more to his employer.

Most employers, when it comes to paying out good money for wages are from Missouri, and have to be shown that the engineer is worth the money. The man who gets the largest salary is usually the one who is trying to reach the top of his chosen profession whatever it may be, and who labors hard at his work instead of trailing along a week or two ahead of the yellow discharge ticket.

Recently a friend sent me a post card on which the following very pertinent verses were printed:

The man who wins is an average man,
Not built on any particular plan,
Not blessed with any particular luck,
Just steady and earnest and full of pluck.

When asked a question he does not guess—
He knows, and answers "no" or "yes."
When set to a task the rest can't do,
He buckles down till he's put it through.

Three things he's learned; that the man who tries
Finds favor in his employer's eyes,
That it pays to know more than one thing well,
That it doesn't pay all he knows to tell.

So he works and studies till one fine day
There's a better job with bigger pay,
And the men who shirked whenever they could
Are bossed by the man whose work made good.

For the man who wins is the man who works
Who neither labor nor trouble shirks,
Who uses his hands, his head, his eyes,
The, man who wins is the man who tries.

J. C. HAWKINS.

Hyattsville, Md.

Our Repudiation

The subjoined correspondence explains itself. Let the American Carbonine Co. appoint an engineer, we will appoint another; these two to select a third. Let the three engineers so selected make an exhaustive test of the value of carbonine.

If by the use of carbonine a given quantity of coal can be made to evaporate 20 per cent. more water than can be evaporated under the same conditions of temperature and pressure with the coal untreated, we will pay the entire expenses of the test and acknowledge that we were mistaken and did carbonine a serious injustice when we published the correspondence and the comment herewith reprintedin the left-hand column below.

If, upon test, the coal treated with carbonine fails to evaporate 20 per cent. more water per unit of weight than can be evaporated under the same conditions of temperature and pressure with the same coal untreated, the American Carbonine Co. shall pay the entire expense of the test and sign an acknowledgment to be printed in the pages of POWER that the attitude of incredulity assumed by this paper in the treatment of carbonine reproduced below was wise and warranted.

Each party to the agreement shall furnish a bond acceptable in amount and terms to the board of experts conditioned upon the faithful carrying out of his portion of the contract.

If carbonine or anything else will save 20 to 30 per cent. of coal and abate the smoke nuisance at the same time, it is worth spending money to find it out.

If carbonine is only another of the various nostrums which have been bobbing up from time to time for the past 20 or more years for the same purpose, exploited in the same way, and failing to sustain the test of real investigation and continued use, it is right that the public should know it.

Editor POWER:

On page 266 of POWER for Feb. 20, there is an editorial headed "Get Rich Quick Schemes," the latter part of which tells about "Carbonine" and how the use of that same powder mixed with water and sprinkled on the coal is supposed to produce a saving of 25 to 26 per cent. in the coal bill. Salem is not the only city in Massachusetts where the promoters of Carbonine have caught some victims, as Fall River has two or three plants which its promoters claim are using Carbonine and for which they claim a saving of 26 per cent. in the coal pile.

It seems that the right way to use Carbonine is to buy one ton, which costs $90. Then take one pound of Carbonine powder and mix it with one gallon of water (hot or cold) it makes no difference. Then to each ton of coal sprinkle eight gallons of this mixture and then you save 26 per cent. of your coal bill. One of the promotors was asked how it was figured out that adding 67 lb. of water to a ton of coal aided the combustion of the coal, and he answered that he did not know. "You could use Carbonine without water," he said, but adding water made the mixture go farther. You could get the same results by using it dry. The writer agrees with him, and also believes he can get the same results by leaving out the Carbonine, ...

Fall River, Mass. MICHAEL H. HARRINGTON.

[The sample accompanying the letter above was sent without comment to Dr. C. E. Lucke, of Columbia University, for analysis, and by him submitted to a firm of industrial chemists whose report is reproduced herewith.—EDITOR.]

M. C. WHITAKER, M.Sc. F. J. METZGER, Ph.D.

CONSULTING
INDUSTRIAL AND ENGINEERING
CHEMISTS

BROADWAY AND 116TH STREET
NEW YORK CITY

June 11, 1912.

Prof. C. E. Lucke,
Columbia University.

Dear Dr. Lucke:

We have made a qualitative analysis of the sample of material forwarded on June 5th with your letter from Power. We find that this material is practically all common salt mixed with some potassium permanganate and some zinc compound. We also note small quantities of carbonaceous material and a little sulphate.

The stuff looks to us very much like some of the fake ash burning compounds which are put out and which we have had occasion to examine before.

Hoping that you will find this satisfactory.

Very truly yours,

M. C. Whitaker

MONTREAL, CAN. PARIS, FRANCE

AMERICAN CARBONINE CO.

"CARBONINE, THE COAL ECONOMIZER"

170 [illegible] STREET

BOSTON, MASS.

October 23. 1912.

Mr.F.R.Low
Editor Power Magazine
505 Pearl Street
New York, N.Y.

Dear Sir:-

It has just been brought to my attention,the article regarding Carbonine in your issue of July 9th 1912, signed by a Michael H.Harrington,Fall River,Mass.

It is very evident that you have not looked into this to any great extent. Now in the first place I want to set matters right.

The American Carbonine Co.Inc.,is not a get rich quick scheme,nor a fake. Carbonine is not a fad nor an experiment. It has been used in Canada for more than two years, would refer you to advertisement appearing in the Canadian Manufacturer,September issue 1912.

Carbonine is sold on its merits. We do not claim it is a substitute for coal,neither do we claim any heat units in Carbonine alone. We do claim this,when combined with coal, "Carbonine" a catalytic chemical which has an affinity for coal, which affiliates with it,and facilitates its combustion,consuming the volatile gases at the proper ignition point, utilizing them as heat efficiency instead of allowing them to pass out un-burnt and un-consumed as un-altered hydro-carbon and carbon monoxide.

It produces a practically smokeless combustion,saving from 20 to 30% in the amount of coal required for the production of a given result.

The so-called coal experts report is incorrect. There have been about forty chemists analyze Carbonine,and their reports vary, yet Carbonine is made the same to-day as it was nearly three years ago.

You undoubtedly know that the Pears Soap people offer a considerable sum of money to anyone who will tell them exactly the ingredients in Pears Soap. It is an undisputed fact that there are chemicals that cannot be analyzed. The important question is not what or how an article is made,but the results it produces, the practical is what the public demand. A thing should not be condemned until a fair trial or test is given it. Sometimes people are sore-heads, so called, because they cannot have their own way.

Carbonine is an article that will stand alone on its merits,if given a fair and practical test,this had to be proven before patent rights could be secured. We want you to repudiate the incorrect statements in the issue of July 9th in "Power" or else prove the statements.

Yours very truly,
American Carbonine Co.
W. A. Dunham
Treas.

WAD/B

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Deflection of Line Shafting

What amount of deflection is allowable for line shafts?

W. H.

For continuous line shafting the bearings should be spaced near enough together so that the deflection will not exceed 0.01 in. per ft. length of shafting.

Danger with Siphon Condenser

Is there any danger of getting water in the cylinder of an engine with a siphon condenser?

S. M. O.

Yes; from stoppage of the tail pipe or a reduction of the effective head of the tail water, to less than 34 ft., which might happen from air backing up in the tail pipe.

Slip of Pump

What is meant by the percentage of slip of a pump?

P. M.

The difference between the volume of water-piston displacement and volume of water actually pumped is the slip of the pump; and the per cent. which this difference is of the volume of water-piston displacement is the percentage of slip.

Flywheels for Jackshaft

In driving a belted electric generator from an engine jackshaft which has unsteady speed, due to lightness of the engine flywheel, can the speed of the generator be made steadier by placing a flywheel on the jackshaft?

W. H. S.

Uniformity of the jackshaft speed would be improved by any addition of flywheel weight within the limits of disturbance of speed that might be introduced by creating an unsteadiness of the engine belt.

Tobin Bronze

What is the composition and tensile strength of Tobin bronze?

J. B.

The composition is usually about as follows:

	Per cent.
Copper	59
Zinc	38.4
Tin	2.16
Iron	0.11
Lead	0.31

As cast metal it has a tensile strength of about 65,000 lb. per sq.in. of sectional area; when rolled, about 79,000 lb.; and when drawn down by cold rolling a tensile strength of over 100,000 lb. per sq.in.

Loss of Heat by Steam Pipe

With the average temperature of a boiler room at 85 deg. F., what is the loss of heat per running foot of bare 7-in. iron steam pipe containing steam at 110 lb. boiler pressure?

A. M. W.

The rate of transfer of heat from bare wrought-iron or steel steam pipe is about 2.7 B.t.u. per sq.ft. of radiating surface per hour, for each degree Fahrenheit difference of temperature between the steam inside and air outside of the pipe. Steam at 110 lb. boiler pressure would have a temperature of 344.4 deg. F. and as the difference of temperature would be

$$344.4 - 85 = 259.4 \text{ deg. F.}$$

the loss would be

$259.4 \times 2.7 = 700.38$ *B.t.u. per sq.ft.* of external pipe surface per hour. The outside diameter of 7-in. pipe being 7.625 in. its circumference is 23.94+ in. and the external area

$$(23.94 \times 12) \div 144 = 1.995 \text{ sq.ft. per running foot}$$

The loss is therefore, about

$$700.38 \times 1.995 = 1397.2$$

or in round figures, 1400 B.t.u. per hr. per running foot of pipe.

Air Bound Suction Pipes

What causes a suction pipe to become air bound and how can it be prevented?

A. K.

Water generally contains air or other gas in solution at atmospheric pressure. When the pressure is relieved the gases, which are held in solution or in suspension, are liberated in small bubbles, as may be observed in the boiling action of water when placed in a vessel under the glass receiver of an air pump. In like manner small bubbles of air are liberated from the water of a pump suction pipe and attaching themselves to the walls of the pipe they are not readily disengaged from cavities and rough spots of the pipe surface, and increase in size by contributions of air from additional water flowing through the pipe, often resulting in complete stoppage of the pipe area. Air bubbles are likely to be thus formed in any siphon or pump suction pipe, but can generally be dislodged by sharp taps of a hammer and discharged through petcocks placed at the highest points of the pipe line. The best method of preventing the liberation of air is to employ large size suction pipes and pumps large enough to be operated at a slow rate of piston speed.

Coal Required

How many pounds of coal will be required to raise the temperature of 200,000 lb. of water from 50 deg. F. to 180 deg. F. the coal having a calorific value of 13,000 B.t.u. per lb.?

E. S.

To raise the water from 50 deg. F. to 180 deg. F. would require, approximately

$$200{,}000 \times (180 - 50) = 26{,}000{,}000 \text{ B.t.u.}$$

Allowing a boiler efficiency of 70 per cent. the heat received from combustion of each pound of coal would be 70 per cent. of 13,000 = 9100 B.t.u.; hence the coal required would be

$$\frac{26{,}000{,}000}{9100} = 2857+ \text{ lb.}$$

Power Absorbed by Friction of Shafting

What is the formula for the number of horsepower absorbed by the friction of shafting?

J. G.

The average coefficient of friction of iron or steel shafting in horizontal bearings is about 0.07 for ordinary oiling and about 0.043 for continuous oiling. Where d = the diameter of the journal in inches, the space passed over for one turn would be

$$\frac{3.1416 \times d}{12} = 0.26\, d \text{ ft.}$$

hence for each journal bearing where

W = Total weight of shafting and pulleys, plus the resultant stress of belts, in pounds;
d = Diameter of the journal in inches;
T = Number of turns per minute;
h = Number of horsepower absorbed, then for ordinary oiling the formula is

$$h = \frac{0.07 \times W \times 0.26\, d \times T}{33{,}000} = \frac{W d T}{1{,}813{,}187}$$

and for continuous oiling

$$h = \frac{0.043 \times W \times 0{,}26\, d \times T}{33{,}000} = \frac{W d T}{2{,}951{,}699}$$

Engineers' Study Course

The promised Engineers' Study Course commences with this issue. The necessary mathematical foundation will be laid by a brief review of fractions, percentage, proportion, roots and powers, the use of logarithms, formulas and equations, mensuration, simple trigonometry, etc. These subjects will be carried along in an easily understandable way and be replete with engineering examples so that the student will learn not only how to read and understand mathematical expressions and to perform the computations arising in his work, but will gain much practical engineering knowledge in the process. The course will then take up elementary mechanics, simple chemistry, heat physics, boiler and engine testing, power plant economics, etc. As space permits and it proves practicable, treatment of the more advanced topics may be undertaken in the same issue with the more elementary lessons, that a wider range of readers may be interested and the beginner see where his studies are leading him.

As the course progresses the student will be referred to books, papers and articles which may be consulted for further knowledge upon the particular subject in hand.

In order that one may understand later lessons and perform the examples which will be given in this course, he must have a working knowledge of arithmetic. It is to be presumed that anybody who will wish to follow it can already add, subtract, multiply and divide, but it may be well, even at the expense of keeping most of the class waiting, to brush up a little on fractions.

A shaft that was one whole piece, that was "integral" as they say, not made up of a lot of separate parts but a complete unity, breaks into two parts; *fractures*.

The safety valve sticks and a boiler is blown into *fragments*.

These words, signifying breaking up, dividing, come from the same Latin word as "fraction" which means also, when we use it to represent an action, the dividing or breaking of a thing into parts, and when we use it to represent a thing, one of the parts into which the object is divided.

In Fig. 1 is a circle divided into 12 equal parts. Each of these parts is "one-twelfth" or $\frac{1}{12}$ of the whole circle. If we want to specify how much of the circle is shaded we see that five of the subdivisions are so treated and say that $\frac{5}{12}$ of the circle is shaded.

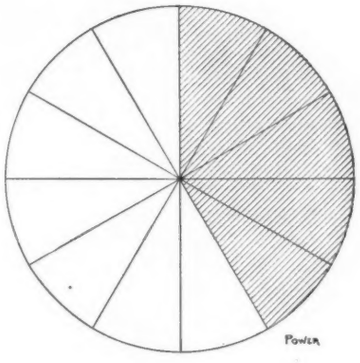


FIG. 1

This expression $\frac{5}{12}$ is a fraction. It expresses a part of something, a *fragment* of something, and tells what part this fragment is of the whole.

We have just been through the excitement of naming, or *nominating* candidates for the presidency. Denominate means a little more strictly to call by name, to classify, to specify. What *denomination* does he belong to? When you draw money from the bank you tell the teller whether you want it in bills of large or small *denomination*. The figure under the line is called the "denominator" because it names, specifies, tells, denominates what kind of parts we are dealing with, whether they are halves or quarters or $\frac{1}{8\,1\,0}$ths or what. It is the number of parts into which the whole object, the "integer," may be assumed to be divided in order that by specifying a certain number of these parts we may express the quantity desired. When we said above that $\frac{5}{12}$ of the circle was shaded, what we virtually said was that if the circle were divided into 12 equal parts, the part which was shaded would equal five of these.

The number above the line (5 in this instance) is the *numerator* because it numbers, counts off or numerates how many of these parts are to be taken.

The expression $36 \div 12 = 3$ means that 36 divided by 12 equals 3.

Put the numbers themselves in place of the dots over and below the line, placing the number to be divided on top, and you will have a simpler expression which means the same thing, thus

$$\frac{3\,6}{1\,2} = 3$$

A fraction then is simply an expression of division, and means that the numerator is to be divided by the denominator.

When the numerator is less than the denominator the quotient will be less than one, as in

$$\frac{\textit{numerator}}{\textit{denominator}} = \frac{5}{12} =$$

Here the quotient of 5 divided by 12 is less than *one*. It is only that part of one that the shaded part of the little circle after the fraction is of the whole circle. The expression therefore signifies a fragmentary, a fractional, part. It is properly a fraction and is called a "proper fraction."

When the numerator is greater than the denominator, the quotient will be greater than one, as

$$\frac{3\,6}{1\,2} = 3 \qquad \frac{2\,5}{6} = 4\frac{1}{6}$$

Divisions expressed in this way in which the numerators are greater than the denominators, are called "improper" fractions, which, however, is quite a different thing from "vulgar" fractions, which means fractions written with a numerator and denominator as $\frac{1}{2}$, as opposed to decimal fractions whose denominators are implied by the position of the decimal point and must be multiples of 10. The vulgar fraction, notwithstanding its vulgarity or commonness, can express any known quantity with absolute precision, while the decimal fraction can express it exactly only when its denominator will divide its numerator without a remainder when sufficient ciphers are added to the numerator. So it comes about that the common or vulgar fraction is used for the most refined calculations, and its pretentious relative, the decimal, is discredited altogether when it comes to the higher mathematics.

I have given you two conceptions of a fraction, the first when I cut a circle up into 12 equal parts and called this number of parts the denominator and then took a certain number of these parts and called this number the numerator; and the other when I said that it was a sign or expression of division; a direction to divide the numerator by the denominator. Just to show that it makes no difference which way we look at it, here, Fig. 2, is a foot rule divided into inches or 12ths. We want to express or specify the part of this foot which is occupied by three of these inches.

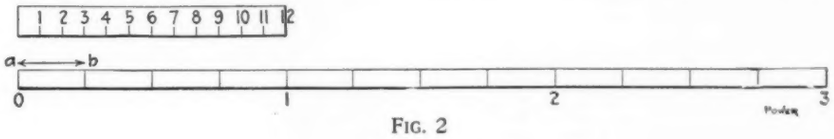


FIG. 2

Well, in one way we conceive of the rule being divided into 12 equal parts, and 12 is the denominator, and we are

talking about three of these parts, so 3 becomes the numerator and the expression becomes $\frac{3}{12}$ or the length *ab*.

In the other conception of the fraction, that of an expression of division, we take three foot rules or a three-foot rule and divide this into 12 equal parts, as in the lower part of the same figure. The result *ab* is the same as before. In one case we divide a 1-ft. rule into 12 parts, and multiply by 3 (i.e., we take one part three times) and in the other case we multiply by the 3 first and then divide the product by 12. In both cases the numerator is the multiplier and the denominator the divisor.

Remember that! Quantities above the line are multipliers; quantities below the line, divisors.

Mixed numbers are those consisting of a whole number or integer and a fraction as $3\frac{1}{2}$; $68\frac{3}{4}$; $79\frac{11}{12}$.

We must first learn to express these mixed numbers as improper fractions. It is very simple.

To Reduce a Mixed Number to an Improper Fraction

RULE: *Multiply the integer or whole number by the denominator of the fraction.*

To the product add the numerator of the fraction, and write the sum as a numerator over the denominator.

EXAMPLE: Express $3\frac{1}{2}$ as an improper fraction.

Multiply the integer (3) by the denominator (2)

$$3 \times 2 = 6$$

add the numerator 1

$$7$$

Write the sum (7) over the denominator (2), then

$$3\tfrac{1}{2} = \tfrac{7}{2}$$

EXAMPLE: Reduce $329\frac{19}{64}$ to an improper fraction.

329 integer
64 denominator

1316
1974

21056 integer × denominator
19 numerator

ans. $= \frac{21075}{64}$ int. × denom. + nu. / denominator

One addition may be saved by adding the numerator right in with the addition for the multiplication, thus

329
64

1316
1974
19

$\frac{21075}{64}$

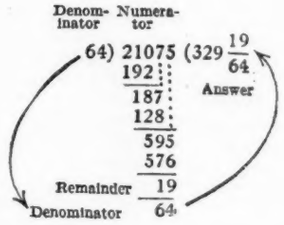
To Reduce an Improper Fraction to a Mixed Number

RULE: *Divide the numerator by the denominator for the integer part and write the remainder over the denominator for the fractional part.*

EXAMPLE: Express $\frac{7}{2}$ as a mixed number.

From a group of seven articles we may take two away three times and there will be still one left. This is what is meant when it is said that 2 will "go into" 7 three times and leave one as a remainder. We write the quotient 3 as the whole number, and write the remainder (1) over the denominator (2) for the fractional part, giving $3\frac{1}{2}$ for the answer.

EXAMPLE: Express $\frac{21075}{64}$ as a mixed number.



Examples for Practice

1. The length of an indicator diagram is $3\frac{19}{64}$ in. What is its length in 64ths?

2. A pump rod is $\frac{25}{16}$ in. in diameter. What is its diameter in inches and 16ths?

3. A boiler tube contains 1680 sq.in. of heating surface. Since there are 144 sq.in. in a sq.ft., this will equal $\frac{1680}{144}$ sq.ft. Reduce this to a mixed number.

4. A vessel contains 4275 cu.in. of water. There are 231 cu.in. in a gallon. How many gallons of water does the vessel contain?

5. An engine uses 6000 lb. of steam per hour and develops an average of 324 hp. How many pounds of steam does it use per horsepower-hour?

6. A boiler evaporates $8\frac{1}{8}$ lb. of water per pound of coal. Express this as an improper fraction.

7. What mathematical operations are indicated by the expressions:

$$\frac{12}{4} \qquad \frac{circumference}{diameter} \qquad \frac{a}{b}$$

8. What is a whole number, an entire quantity, called?

9. In a fraction, what is the number above the line called?

10. In a fraction, what is the number below the line called?

11. Write the expression $21 \div 5$ in the form of a fraction.

12. In the expression $\frac{17 \times 4}{3}$, what is the numerator and what is the value of the expression written as a mixed number?

Study Question Answers

On account of the Engineers' Study Course, beginning in this issue, the Study Questions will be discontinued. The answers to the last five questions given in the Oct. 29 issue follow:

(121) The electromotive force of each group will be

$$5 \times 2 = 10 \text{ volts}$$

and the internal resistance

$$5 \times 0.04 = 0.2 \text{ ohm}$$

But since there are five groups in parallel the internal resistance of the battery is

$$\frac{0.2}{5} = 0.04 \text{ ohm}$$

Hence the total resistance, both internal and external, is

$$0.5 + 0.04 = 0.54 \text{ ohm}$$

Therefore the current in the circuit will be the total electromotive force divided by the total resistance, or

$$\frac{10}{0.54} = 18.5 \text{ amp.}$$

(122) 1 hp.-hr. = 1,980,000 ft.-lb. of energy. As

$$Energy = pressure \times volume = PV$$
$$1{,}980{,}000 = PV$$

As the volume is to be expressed in cubic feet, the pressure must be in pounds per square foot. Hence

$$P = (60 - 2)\ 144 = 8352 \text{ lb.}$$

Then

$$V = \frac{1{,}980{,}000}{8{,}352} = 237.07 \text{ cu.ft. per hr.}$$

Dividing this by the specific volume given

$$\frac{237.07}{7.037} = 33.69 \text{ lb.}$$

of steam used (or water evaporated) per horsepower per hour.

(123) Let

x = Time first outlet is open;
y = Time second outlet is open.

Then

$$x + y = 10 \text{ min.} \qquad (1)$$

Discharging 14 and 9 gal. per min. respectively

$14x$ = Quantity discharged by first outlet;
$9y$ = Quantity discharged by second outlet.

From the conditions of the problem

$$14x + 9y = 100 \text{ gal.} \qquad (2)$$

Multiplying equation (1) by 14

$$14x + 14y = 140$$

Subtracting equation (2) from this

$$5y = 40$$
$$y = 8$$

and substituting in (1)

$$x + 8 = 10$$
$$x = 2$$

(124) The length of the tank, head to head, will be 6 ft. minus 3 in., or

$$6 - \tfrac{1}{4} = 5\tfrac{3}{4} \text{ ft.}$$

The diameter will be that of a circle having a circumference of

$$6 - \tfrac{1}{4} = 5\tfrac{3}{4} \text{ ft.}$$

As the circumference of a circle equals the diameter multiplied by 3.1416

$$5.75 = 3.1416\ D$$

$$D = \frac{5.75}{3.1416} = 1.83\ ft.$$

The volume of the tank will be that of a cylinder of the dimensions now determined, for the reduction of volume due to the concave head is equal to the increase of volume due to the convex head. Hence the volume is the cross-sectional area multiplied by the length, or

$$0.7854 \times (1.83)^2 \times 5.75 = 15.124\ cu.ft.$$

(125) The uniform load of 800 lb. per ft. of length may be regarded as a concentrated load of

$$800 \times 24 = 19{,}200\ lb.$$

applied through the center of gravity, which will be the middle of the beam. Taking a summation of moments around the right support, its moment then will be

$$19{,}200 \times 12 = 230{,}400\ lb.\text{-}ft.$$

and the moments of the concentrated loads will be

$$5000 \times 24 = 120{,}000\ lb.\text{-}ft.$$

and

$$9000 \times 8 = 72{,}000\ lb.\text{-}ft.$$

The opposed resistance is that of the left support, call it X and its moment will be $X \times 20$. Equating

$$20X = 230{,}400 + 120{,}000 + 72{,}000$$

$$X = 21{,}120\ lb.$$

As the sum of the loads must equal the sum of the reactions

$$21{,}120 + Y = 5000 + 19{,}200 + 9000$$

$$Y = 12{,}080\ lb.$$

and is the load on the other support.

ERRATUM: In the answer to study question No. 95 in the issue of Sept. 24, a typographical error appeared, the figure 1 being lost before the 8 in the number of seconds for the second acute angle. The answer should have been 51 deg., 20 min., 18 sec.

Exhibition of Products "Made in Minneapolis"

The Civic and Commerce Association of Minneapolis, which is promoting "Made in Minneapolis" week, expects to have at least 500 exhibits of Minneapolis made goods in the business district. General Manager Pack, of the Minneapolis General Electric Co., has donated all the power needed for the operation of exhibits during the week, and in addition, all the lighting necessary. Arrangements have already been made for the electric operation of 100 working models of manufacturing processes on the streets and in the windows of the retail stores.

The company will have in its window an electric freight train in operation. On this train will be loaded various products of Minneapolis manufacturers.

Salaries of School Engineers in Chicago

The daily papers of Chicago recently published figures relating to the salaries paid to the public-school engineers in that city. The figures as given were exceedingly interesting and if correct would have indicated that the public-school engineers of Chicago were among the highest paid men to be found in the profession.

Investigation showed the papers had not told the whole story, however, for while the gross salaries received by some of the engineers are large, they must pay all their assistants out of the money they receive from the city.

The most spectacular case cited was that of the chief engineer of the Bowen High School, whose gross salary was reported as $9065.04 per year. His salary actually is $8465.04, out of which he must pay for the assistance required to take care of the heating plant, do all the sweeping and cleaning required throughout the building and care for the walks and the lawns which belong to the school.

The building contains some hundred rooms which, with the corridors, have 167,000 sq.ft. of floor surface to sweep and clean. The cleaning must be done in a specified manner and at specified intervals. Adjoining the building is a space of one city block used as a botanical garden, the care for which must be provided by the engineer. Thus it will be seen that the engineer is really a superintendent, for the entire building and grounds and as such is responsible for maintaining them in good condition.

A fair estimate of the help required at the Bowen High School follows:

	Months per Year	Wages per Month	Wages per Year
One assistant engineer	12	$100	$1200
One fireman	12	80	960
One coal passer	8	70	560
One coal passer	3	70	210
One man for cleaning	10	70	700
One woman for cleaning	10	40	400
Four women for cleaning	10	35	1400
One man for walks and lawns	12	90	1080
Total			$6510

Thus, on a fair estimate the engineer must pay out $6510 per year to his assistants. This, from $8465.04 leaves $1955.04 as his compensation, which is not exceedingly liberal, considering his responsibility and that during some months in the year he must be at the school very early each morning to see that it is suitably heated in time.

Even assuming that by dint of hard manual work on his own part and by exercising good judgment he is able to reduce the above estimated expenses 10 or 15 per cent., his income is not unduly high when compared with the pay received by men in similar positions with private concerns.

Over the Spillway

Just Jests, Jabs, Joshes and Jumbles

Constable Joe Ash will be promoted for good detective work when our police force is increased to two, says the *Cinders Siftings*. Joe writes us: "I ketched Slicebar an' Hoe aplayin' poker over in the Clinkerton b'iler room an' jugged 'em. Ain't that grate?"

MANAGER—There's a man loafing back of the heater.

CHIEF—That's Brick, my assistant.

MANAGER—You fire Brick!

It is decidedly adventitious for Aleck Smart to ask who put the vent in ventilator. Why not interrogate us as to the identity of the individual who put the nick in our last nickel and made us walk home?

Bud Sykes was a meddlesome joker
Who worked with a shovel and poker.
One day he got gay—
(The chief was away)
He took up the engine and broke 'er.

Waxing eloquent, a contemporary remarks that "a microscopic eye is needed in the perpetual chase after the recalcitrant heat unit." We are immune from the "pink-eye" and the use of the capital "I," but this microscopic type is an eye-bolt that holds us mentally suspended by our galluses over unknown terrors.

BUTT STRAP—Old man Rivet looks het up.

STAY BOLT—Ya-as. Rivet went into the boiler shop on business and was thrown into the fire. Made him hot under the collar. Then he got hit on the head several times and found himself in a hole. Rivet has cooled off quite some, but he's upset about it.

After two years' work, says the *Universal Engineer*, the Strawberry Tunnel, in Utah, has been pierced, and the paper further remarks that the valley to be irrigated is especially interesting because it was settled by Bingham Young. As friend Brig. was some "engineer" in his prime, it would be further interesting to know who settled Brigham.

Highbrow politicians are dipping into our engineering preserves for their metaphors. T. R. has been called a "switch-engine," and La Follette a "donkey-engine." Our water-power possibilities ought to appeal to the Prohibitionists.

N. A. S. E. Anniversary Banquet

The subordinate associations in Chicago of the National Association of Stationary Engineers held a stag banquet at the La Salle Hotel on Saturday evening, Oct. 26, to commemorate the thirtieth anniversary of the organization's birth and to honor the newly elected national president, John F. McGrath, who is a member of Illinois No. 28 of Chicago. Over 300 members and guests sat down to the feast. After the banquet, National Secretary Fred W. Raven introduced John W. Lane, editor of the *National Engineer*, as the toastmaster. James C. ("Dad") Beckerleg, the first national treasurer and the second national president of the organization, spoke reminiscently of the small beginnings of the association in New York City just 30 years ago. He said that its splendid growth and progress made proved that while men may come and men may go the association will live on and prosper, because it is founded on sound principles and is a force for good.

Col. Henry A. Allen, chief engineer of the Chicago water-works system, gave some interesting facts and figures concerning the development and present size of the system and in concluding extended an invitation to all present to visit the various pumping stations and offer any helpful criticisms of them.

Prof. William J. Bogan, of the Lane Technical School, spoke on modern educational problems. Although the first purpose of the public schools is to make good citizens, fully as important is the development of judgment and initiative. In industrial and agricultural America there is need today of the development of systems of education better suited to the requirements of the future business life of the children being educated. He believed that before great progress can be accomplished in this direction we must educate our educators.

Charles W. Naylor, chief engineer of the Marshall Field & Co. properties, spoke briefly.

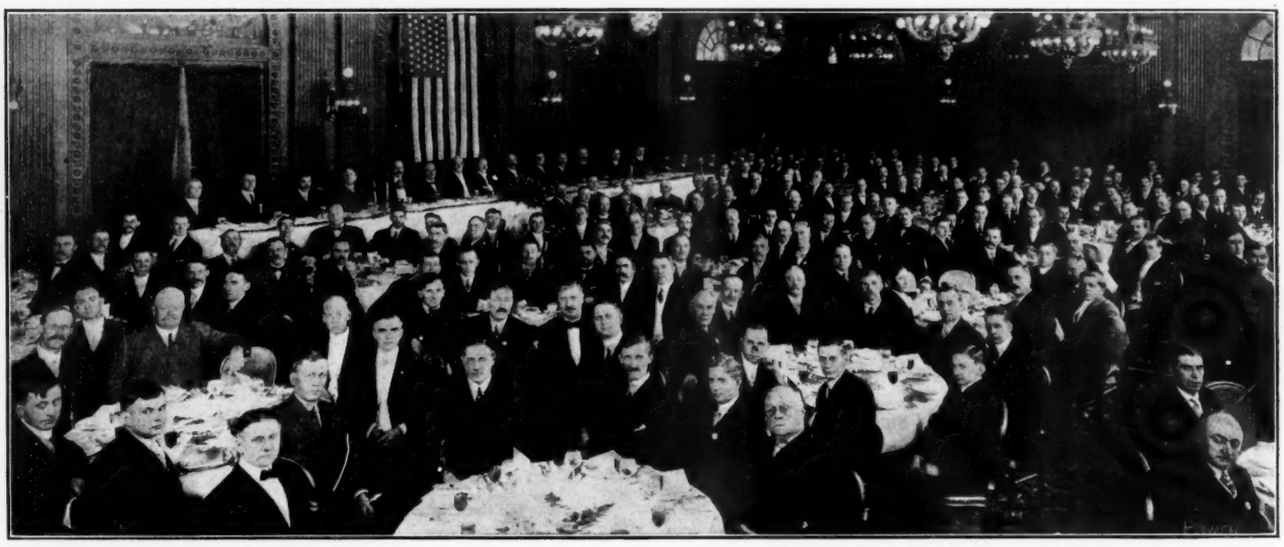
James H. Harris paid a graceful tribute to the character and worth of the guest of honor, John F. McGrath.

Samuel B. Forse, national treasurer, spoke of his work of caring for the funds of the association and contrasted the large sums handled at the present time with the small amounts of which the first treasurer had custody.

The toastmaster then introduced National President McGrath, who bears the distinction of being a man who did not seek the honor bestowed upon him, but rather endeavored to avoid it. President McGrath spoke of the recent trips he has made in the interests of the association and stated that he was well pleased with the healthy, active and enthusiastic condition in which he found the numerous subordinate associations throughout the country.

He stated that he would do his utmost in furthering its work and policies and fervently hoped that his successor would find the organization in as good or even better condition when he came into office a year hence.

Interspersed with the speeches were numerous musical numbers, generously provided by the Ted Snyder Music Co. and Messrs. Fred S. Hickey, of the Dearborn Drug & Chemical Works, and Sam Rosenthal, of the Fred Busse Coal Co.



GUESTS AT THE BANQUET CELEBRATING THE THIRTIETH ANNIVERSARY OF THE N. A. S. E.

Through an error in making up the list of exhibitors at the recent national convention of the N. A. S. E. in Kansas City, the names of the C. Lee Cook Manufacturing Co., Louisville, Ky., and the Metallic Packing & Manufacturing Co., Elyria, Ohio, were omitted from the report in the Sept. 24 issue. We regret that this error should have occurred and take pleasure in making the correction.

Hartford Wins in Pabst Suit

The United States Circuit Court of Appeals at Chicago has decided in favor of the Hartford Steam Boiler Inspection & Insurance Co. in a suit brought against it about a year ago by the Pabst Brewing Co., of Milwaukee.

Several important questions were involved, chief among which was the brewing company's contention that the failure of each of the three boilers was a separate explosion, and that the insurance company was liable for the limit of the policy, $50,000, for each explosion. The brewery company also claimed that the insurance company's inspection was imperfect and it was therefore liable for the entire loss. The Circuit Court of Appeals reverses the decision of the trial court and finds that there was but one explosion; therefore the Hartford company's liability is limited to $50,000 as provided in the policy.

The evidence adduced by the Pabst company that as portions of boilers Nos. 5 and 6 did not explode and therefore proved the condition of boilers Nos. 1, 2 and 3, that did explode, was declared inadmissible. The court also found that if Feliber, Pabst's engineer, knew that the boilers were not in the same condition as at the insurance company's last inspection, Pabst should not have relied upon the Hartford inspector's reports, and that if cracks in boilers Nos. 1, 2 and 3 should have been discovered by Feliber, the jury should have found for the insurance company.

The insurance company paid the Pabst Brewing Co. the $50,000 it claimed it

owed under the policy and the brewery company instituted suit for the balance it claimed was due it.

Details of this explosion were given in POWER of Nov. 9, 1909, page 771; Nov. 23, 1909, page 875, and Feb. 8, 1910, page 285.

Webb City (Mo.) Mine Boiler Explosion

On Oct. 18, a boiler explosion at the Joe Lewis Mine, Webb City, Mo., at 10 a.m., killed a hoister man and a timberman. The boiler circled hundreds of feet above the ground, and fell through the roof of the Meinhart greenhouse.

Joseph Lewis, owner of the mine, who was standing by the smoke-stack, was hurled 30 ft., but received only a few bruises. Two miners, who were working 80 ft. down in the shaft, were taken from the mine by workers from the Robertson mine, adjacent to the Lewis shaft. Neither of the men was aware of the accident until they were taken from the ground and told what had occurred.

It is believed that an excessive pressure of steam caused the boiler to burst, but as there was no one in the boiler room at the time of the explosion the cause is not definitely known.

NEW PUBLICATIONS

THE PRINCIPLES OF PARALLEL PROJECTING-LINE DRAWING. By Alphonse A. Adler, B. S., M. E. D. Van Nostrand Co., New York City. Cloth; 66 pages; 6x9 in.; 48 illustrations. Price, $1.

While this is intended as Part I of the author's "Theory of Engineering Drawing" it possesses the merit of a work complete in itself on the construction of parallel projecting line drawings in oblique, orthographic and axonometric projection. The illustrations and examples are selected with good judgment for enlisting and holding the attention of the student, and the subjects are treated so clearly as to enable the reader to apply the principles for himself in drawing familiar objects, and to discover the road to more advanced knowledge of the subject.

The work, therefore, is a good one for guidance as a class textbook or for self-instruction in the fundamental principles of projection.

TABLES AND OTHER DATA FOR ENGINEERS AND BUSINESS MEN. Compiled by Chas. E. Ferris, B. S., professor of mechanical engineering, University of Tennessee. University Press, Knoxville, Tenn. Morocco; 170 pages, 2¾x5¾ in. Price, 50c.

The seventeenth edition of this little work makes its appearance in the form of a vest pocket-book containing tables of circles, weights of materials, trigonometrical functions, factors of evaporation and other tables and data which are in constant demand by a busy engineer. Power engineers will be especially interested in tables of sizes of boiler tubes, iron pipe, flow of steam through pipes, calorific value of fuels, forced-draft capacity table for blowers, horsepower of waterwheels, wiring tables and a table of equivalent values of electrical and mechanical units.

It is to be noted, however, that the steam tables and table of equivalent evaporation from and at 212 deg. F., are based on the old figures, 965.2 for latent heat of evaporation at atmospheric pressure in place of 970.4 of the Marks and Davis steam tables, which have been more generally adopted by recent authors.

The Coking of Coal at Low Temperatures

Bulletin No. 60 on "The Coking of Coal at Low Temperatures," by F. W. Parr and H. L. Olin, is now ready for distribution, and may be obtained from the University of Illinois, Engineering Experiment Station, Urbana, Ill., at a nominal charge of 25c. The investigations discussed in the bulletin had two general purposes in view: First to discover some fundamental facts pertaining to the properties and characteristics of bituminous coals, and second to determine the feasibility of modifying the composition of raw coal, in order that a different type of fuel might be produced, or possibly an alteration accomplished of the entire fuel contents into forms better suited to present-day requirements. The results obtained, as stated in the summary and conclusion were as follows:

Coals of the Illinois type can be coked at a temperature of approximately 750 to 850 deg. F.

The gaseous products consist chiefly of illuminants of high candlepower, and represent, together with the condensible material, the chief elements involved in the formation of smoke in the ordinary combustion of raw coal. The nitrogen of the coal is liberated as NH_3, at these temperatures, in amounts representing approximately 20 per cent. of the total nitrogen present.

The condensible distillate consists largely of oils with the minimum amount of tar and free carbon. The oils represent positive values for fuel, for carburetting water gas, or for other specific uses on account of their chemical characteristics as unsaturated compounds.

The coke residue has special characteristics which seem to make it of value as a concentrated fuel, capable of combustion without the formation of smoke, suitable for storing without the possibility of spontaneous combustion, and presumably adapted to the manufacture of gas for use in the suction-gas producer.

Certain facts seem to have been developed concerning the principles involved in the formation of coke which may open a way to the production of a kind of coke of such texture and strength as to make it acceptable for uses that are not now possible with coke made from similar coal, but formed under ordinary conditions such as are found in the ordinary gas-house retort practice, or that of the byproduct coke oven.

An appendix gives a resumé of previous studies and research work in the low-temperature distillation of coal.

SOCIETY NOTE

"Measuring Efficiency in Manufacturing" will be the subject of the meeting of the New York members of the American Society of Mechanical Engineers, Nov. 12, 1912, at the Engineering Societies Building, 29 West Thirty-ninth St., New York City. The discussion will be opened with a paper by Edward B. Passano, of Baltimore, Md., who measures efficiency in terms of profit. His position is that all profit should be treated as an item of expense. All loss, through inefficiency, is a potential or a positive profit to be made in enterprise. A reduction in the expense of a business increases the actual profit and the efficiency. This method keeps constantly before the management the actual value of each unit of production to the organization, and the loss through inefficiency which is a potential or possible profit. When a new method is being tried out, such a system will show the benefits or losses which are expressed in actual profit or loss as the work progresses. The discussion will be open to all interested whether members or not.

PERSONAL

Edward H. Lane, an occasional contributor to our columns, and chief engineer of the Commerce Power Co., of Kansas City, Mo., has undertaken the direction of the evening course in stationary engineering at the Y. M. C. A. night school in that city.

Charles H. Bigelow has accepted the position of chief mechanical engineer of the Millville Manufacturing Co., Millville, N. J. Mr. Bigelow recently returned from St. Catharines, Ont., where he had charge of the construction of a factory which will handle the Canadian business of the Yale & Towne Mfg. Co., Stamford, Conn.

At the regular monthly meeting of the board of directors of the Joseph Dixon Crucible Co., held Oct. 21, the following changes in officers and board of directors were made on account of the death of Vice-president William H. Corbin: George E. Long, former treasurer, was elected vice-president to succeed Mr. Corbin; J. H. Schermerhorn, former assistant secretary and assistant treasurer, was elected to membership in the board of directors and treasurer; Albert Norris, assistant secretary and assistant treasurer.

Moments with the Ad. Editor

"A man who never does any more than he is paid for;

Never gets paid for any more than he does."

If you haven't heard this before, it will be well for you to repeat it until you know it, and remember it.

There's a moral in these words.

Imagine a man, if you can, with a pair of balancing scales trying to make the services he is rendering his employer (on one side of the scales) balance the dollars he is receiving from his employer (on the other side).

Such a man will have to do this balancing "stunt" but once, for it's a "cinch," with him, that the dollar side of the scales will never get any heavier.

Money is the most valuable tangible thing in the world.

And money is never exchanged for *anything* except when that thing is considered by the owner of the money to be of more value to him than the *amount* of money he exchanges for it.

This law of exchange applies to other things, as well.

What you exchange, whether it's money or not, is *never* exchanged for anything which you consider of *less* value to *you* than what you offer the other fellow.

Now, your services as an engineer are for sale. The plant owner wants to buy your services. He gives you a job. He gets your services. You get his money in return.

Both of you get the better of the exchange, or it would not have been made.

You are benefited by the exchange because you get money in return—the most valuable tangible thing we know.

Your employer is likewise benefited by the exchange because he, through your services, gets what you get—money.

It's what we all are striving for. We and you will always want more money. It's human nature. And the only way for you to get more money is to make *more valuable* what you give in exchange for the money you get.

But trying to keep your side of the scale from being hoisted in the air by the dollars on the other side means that you will never get paid for any more than you do, which in any event, can be but little.

Render your employer a *maximum* service, always. Then you increase the *value* of your services. Then, the *value* of the exchange, and consequently a bigger return.

Of course, there are many ways in which you can and are increasing the value of your services as an engineer.

For a long time, we have been telling you how much real good you can get out of Power Advertising.

The advertisers in this paper have a service to render or they would not be in the paper.

They are offering you something that will mean a money saving investment in your plant.

Don't be skeptical. Don't be prejudiced. Don't allow yourself to feel that you are doing all you are being paid for.

But make *your* plant a *better* plant. Investigate the claims of these advertisers and their products. Be sure that you have minimized those small wastes which creep into the best and most carefully guarded plants.

Get all you can out of Power advertisers. Investigate their wares. Give them a chance. You've got nothing to lose, at least, by investigating.

You *can* better conditions in your plant—It's not impossible in *any* plant. You can render your plant and yourself a better service.

Don't measure what you do by what you get. Increase the value of your services and the chance for an increased salary will automatically take care of itself.

The selling section of Power offers one way. Get all you can out of it now.